TOWARD A COMPUTER-APPLIED DYNAMIC DWELLING DESIGN MODEL

--- MULTI-FAMILY WALK-UP APARTMENTS IN TAIWAN ---

by
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Submitted to the Department of Architecture on May 10, 1985 in partial fulfillment of the requirements for the Degree of Master of Science in Architecture Studies.

ABSTRACT

It is the objectives of this study to explore the feasiblity of applying a computer in a dynamic dwelling design. Here, the computer is applied to evaluate a support design by testing possible layout variations. A specific type of housing is chosen in the thesis to illustrate the application as well as to explain the theoretical aspects of this model -- a computer-applied dynamic dwelling design model. The thesis includes following five parts:

1. To recognize the form of the specific type of housing. This is done by realizing the backgrounds of the making as well as by observing the use and physical entity of the housing form.
2. To develope a system with explicitly-formulated rules on this specific housing type from the recognition process.
3. To explain the way how to use the system in the decision-making and design-reasoning process of a dynamic dwelling design.
4. To explore the application of a computer in the design process. An example is given here to illustrate the using of this design model.
5. To present a theoretical discussion on the design model which explains the insight backgrounds of the design model.

Thesis Supervisor: N. John Habraken
Title: Professor of Architecture

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CONTENT

CHAPTER 1

CHAPTER 1 INTRODUCTION

1.1 MOTIVATIONS AND OBJECTIVES

Housing and its application have always held my interest throughout my studies in architecture. After exploring the S.A.R.* methodology, I felt that further research in this area would give me a better understanding of decision-making and reasoning in design.

The support design approach has been widely tested in western European countries and has proven to be a successful model to provide variability and adaptability in housing design. However, little research has been done to substantiate its workability in the context of Taiwan. Hence, I decided to direct my study towards a dynamic dwelling* design model in Taiwan.

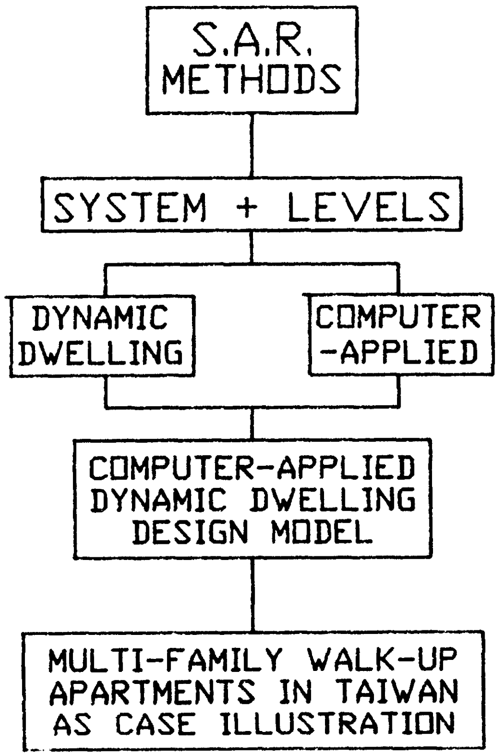
The application of computer-aided design in architecture always presents a lot of potential and challenge to me. By using the computer to assist us in the design process, designers will no longer have to spend their time in many of the ways that have traditionally occupied them, and will be able to concentrate on craetive aspects of design that really matter. In this thesis, I would like to explore the applicability of the computer as a tool

*S.A.R.

Stichting Architecten Research; -- an organization founded in Netherlands in 1964, to conduct architectural research.

*DYNAMIC DWELLING

A dynamic dwelling should provide VARIABILITY -- the abilities to make different or vary while maintaining stability, and ADAPTABILITY -- the abilities to adjust to change in external condition.



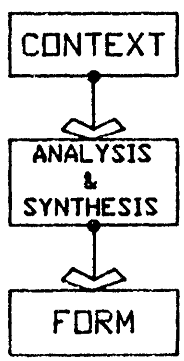
(Fig. 1.1)

computer-applied dynamic dwelling design. It explores the details of the feasibility and design strategy for a dynamic dwelling design. This approach also seeks to understand more precisely how a dynamic dwelling design is executed by exploring design reasoning about physical and spatial relations in the design of a physical form. An application of this model will be illustrated within the contexts of multi-family walk-up apartments in Taiwan to show how this computer-applied dynamic dwelling design model would really work. (Fig. 1.1)

1.2 HYPOTHESIS

Architectural design is a kind of form-making activity. The ultimate object of design is the physical form. In a design, the context defines the problem, while the form is the solution to the problem. Design's function then is to translate the context to the form so as to solve the design problem. The context is that part of the world which put demands on the form. Anything in the world that make demands of the form is context, i.e. all the social/economic and physical constraints.

There is always a leap between context and form. In an attempt to overcome this leap and to connect context and form, designers have often tried to set up some logical structures or mathematic descriptions to represent the problem and hoped the computer could generate forms by means of these logical structures. However, more and more design problems are reaching high levels of complexity and difficulty. It is getting more and more difficult to set up logical structures to exceed the leap between the context and the form. (Fig. 1.2)



(Fig. 1.2)

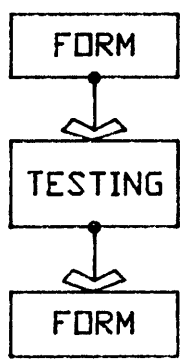
Understanding this task, I am trying to approach the problem in the dynamic dwelling design process.

In a dynamic dwelling design, architects have to evaluate the support design by means of the quality of the dwelling that it makes possible. Using the S.A.R. methodology, I would like to develop a computer-applied dynamic dwelling design model. This design model will not only help an architect or a developer in the evaluation process of a dynamic dwelling design but is also useful for individual residents to plan their own dwelling layouts.

A specific building type is chosen to diminish the size of the computer data base. This enables the use of a personal computer in dealing with this model within its practical computational limits. The multi-family walk-up apartments in Taiwan were chosen as an example here to illustrate the model. I feel this type offers a great challenge as a design issue. The reason is not only because the development of this intensively-used building type serves rapid urbanization and industrialization in Taiwan but also because this existing type, which I am familar with, provides a clear base toward understanding the nature of the problem.

As a whole, this study will generate a tentative model of of the link between context and form from a totally different direction which is more familar to architects -- "form". Starting with form, testing form, and ending up with form, I am trying to avoid the leap between form and context. (Fig. 1.3) This kind of approach also benefits the application of computers in the design process.

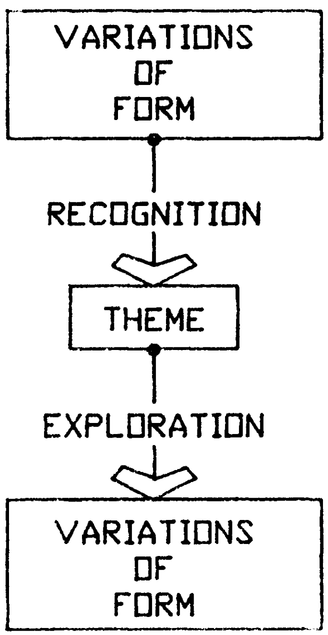
Form always implies a certain context. If we could start with form, we would not have a hard time figuring out all the imposed contexts which make the form. Through our observation about the transformation of the form, we can establish rules about the form as a pre-condition. Then, we arrange spaces and materials based on that understanding. The only premise of this kind of "form-oriented" design model is the maturity of the transformation of the form. The more mature the transformation the form is, the more meaningful the context imposed on it would be.



(Fig. 1.3)

The man-made environment always reveals certain consistent rules which can be used as guidelines for design. The terms "theme" and "variations" are ways of indicating the idea that the environment can be described on the basis of systemic rules and the design can be developed on the basis of that understanding. (Fig. 1.4)

Design consists of two aspects of expertise -- "recognition" and "exploration" -- that help designers make decisions. The recognition ability enables a designer to observe patterns from a set of variations, and to formulate explicit rules to describe them. The exploration ability enables a designer to make variations subject to a given set of constraints.

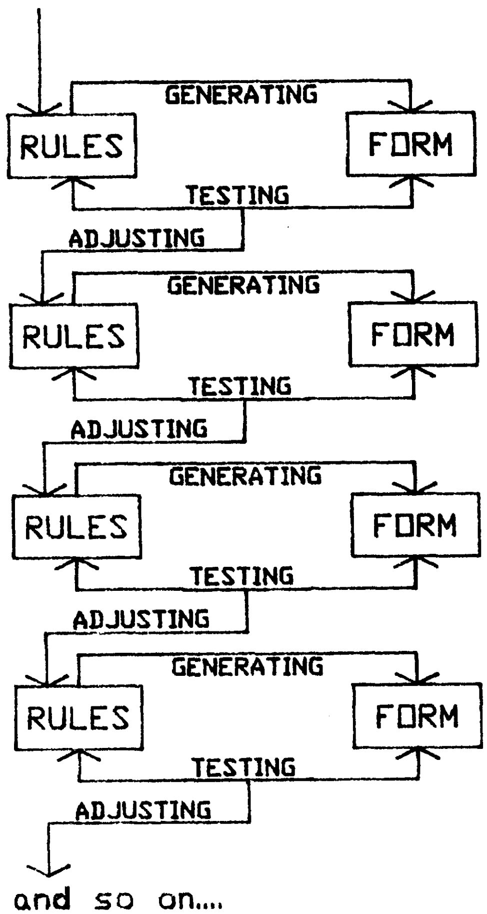


(Fig. 1.4)

In the recognition process of design, the designer observes a mature form with meaningful contexts in it. By recognizing the theme of the form, the designer then can formulate explicit rules on the form. There are always spatial and physical themes in a form recognized as constraints in terms of elements, site, relations between the elements, and position rules on the elements in the site.

In the exploration process of design, the designer organizes spaces and materials based on the understanding from the recognition process. The designer explores the form-making activities by generating, testing, and adjusting the form without setting up any logical structures to link the context and the form. (Fig. 1.3)

In the whole design process, we only deal with the problem of form, both physical and spatial. Design begins with a form and also end up with a form. With this model, we introduce testing to evaluate alternative forms by checking them with outside criteria from a context which must be applied. We then find feasibility and ease in applying computers to the testing process. The input are forms proposed by the designer, the output could be the same form as proposed or evolved ones, and some comments concerning the problems of the proposed forms. (Fig. 1.5) People with needs and resources is the one using this design model to connect the context and the form.



(Fig. 1.5)

The design process is also a kind of developmental process. The design process repeats a series of operations again and again. A decision in one cycle may determine contexts for decisions in the next. The design can be finished completely or decisions can be left unmade for others who join the work later. Using this concept in the dynamic dwelling design model, we introduce the possibility for individual residents to plan and change their own dwellings.

1.3 SCOPE AND FRAMEWORK

The scope of this study is on the dwelling level dealing with the design issues of the dynamic dwelling. (Fig. 1.6) How to generate and evaluate the basic variants in a dynamic dwelling design with the assistance of a computer is the scope of the thesis.

This research emphasizes upon the habitational sphere of a dynamic design in planning variety and change. Little attention was given to the productional sphere dealing with the detailed technical problems of the physical system, such as the materials and details of partitions, storage units, eletrical systems, etc..

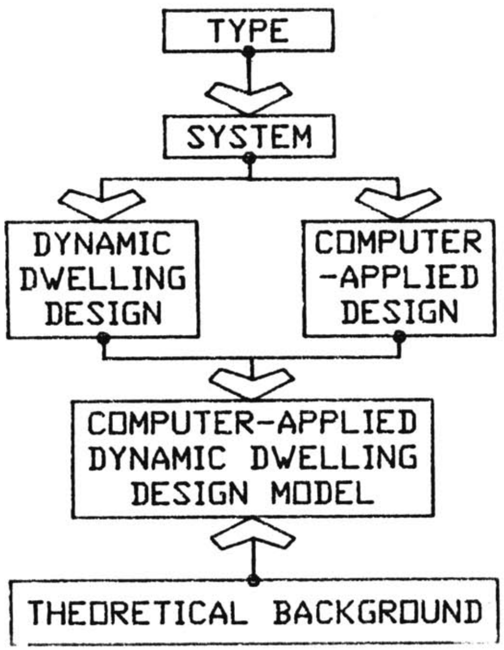
This study starts with a specific type of building -- multi-family walk-up apartments in Taiwan, which I am most familiar with. After I investigated, realizing the background of the making of this type and observed the use and existence of the type, I am trying to describe the form of this specific type of housing in Taiwan. By recognizing the form, I then try to develop a system* with explicit rules for this type of housing. With the system in hand, I will explain the way of using it in the

*SYSTEM

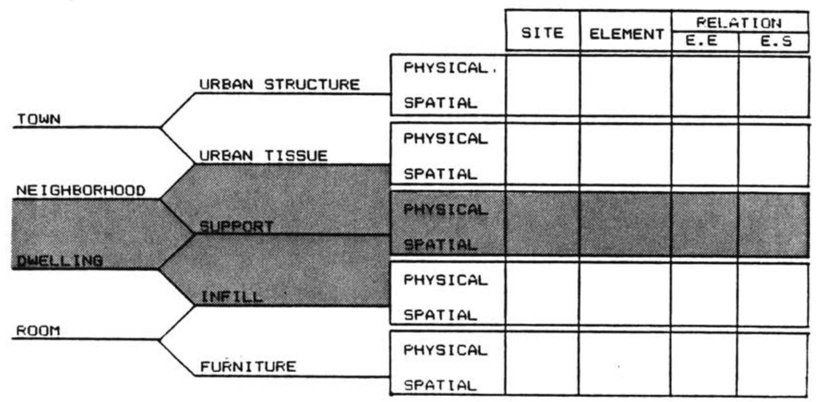
A system can be understood as product of interaction among parts. It is a kit of parts, with rules about the way these parts may be combined.

decision-making and design-reasoning processes of a dynamic dwelling design.

After exploring the design with a system, we can find not only that the system is valuable to be employed in a dynamic dwelling design but also that it is feasibe to apply computers in the design process. This is also an objective of this study -- TOWARD A COMPUTER-APPLIED DYNAMIC DWELLING DESIGN MODEL FOR MULTI-FAMILY WALK-UP APARTMENTS IN TAIWAN. After the model is completed, I will go back to explain the theoretical concepts in the design model. Starting with a specific example, I finally reach a general theory of design. Wider and also deeper applications will be then possible for future research. (Fig. 1.7)



(Fig. 1.7) Frame Work



(Fig. 1.6) Scope

CHAPTER 2

CHAPTER 2 DESCRIPTION OF THE TYPE

The man-made environment always reveals certain consistent rules with which architects can develop systems to use for design. Architectural design is a kind of form-making activity. Architects have to recognize spatial and material patterns in built environments and develop a system from the patterns. Using such a system in design they may explore design to meet specific needs by organizing spaces and materials based on that understanding.

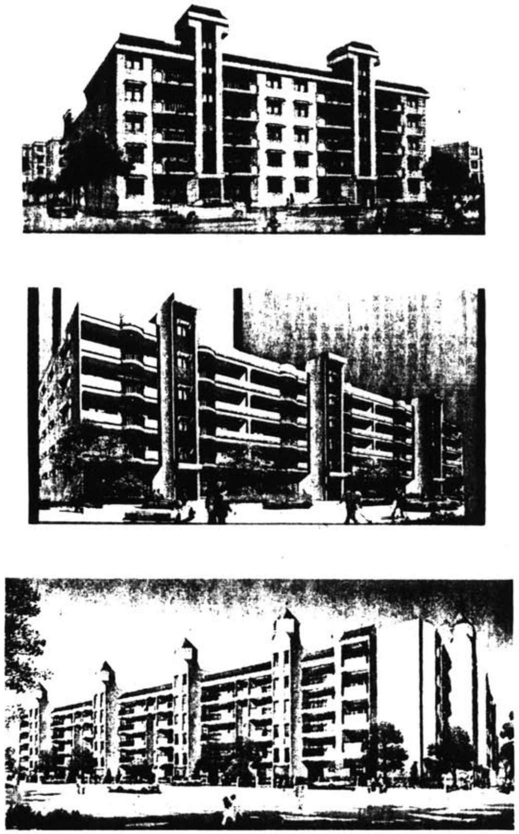
Among contemporary residential buildings, the multi-story residential building is the most prevailing and universal housing type. It is particularly true in rapidly growing urban centers in developing countries. This type of housing represents the living environment for the majority of urban populations.

The multi-family walk-up apartments in Taiwan can be seen as a specific type among contemporary residential building. (Fig. 2.1 a, b) It has both similarities and differences with other forms of multi-story buildings found elsewhere. In Taiwan, the multi-family walk-up residential buildings blend Chinese traditions with Japanese influences. It applies modern building technology, and responds to the specific needs of family life in Taiwan.

(Fig. 2.1a)

2.1 THE "MAKING" OF THIS TYPE

In Taiwan, multi-family walk-up apartment buildings appeared in late 1950's. At that time, a thrust in economic and industrial developments created a demand for urban housing. The form of this type of housing has evolved with following factors:



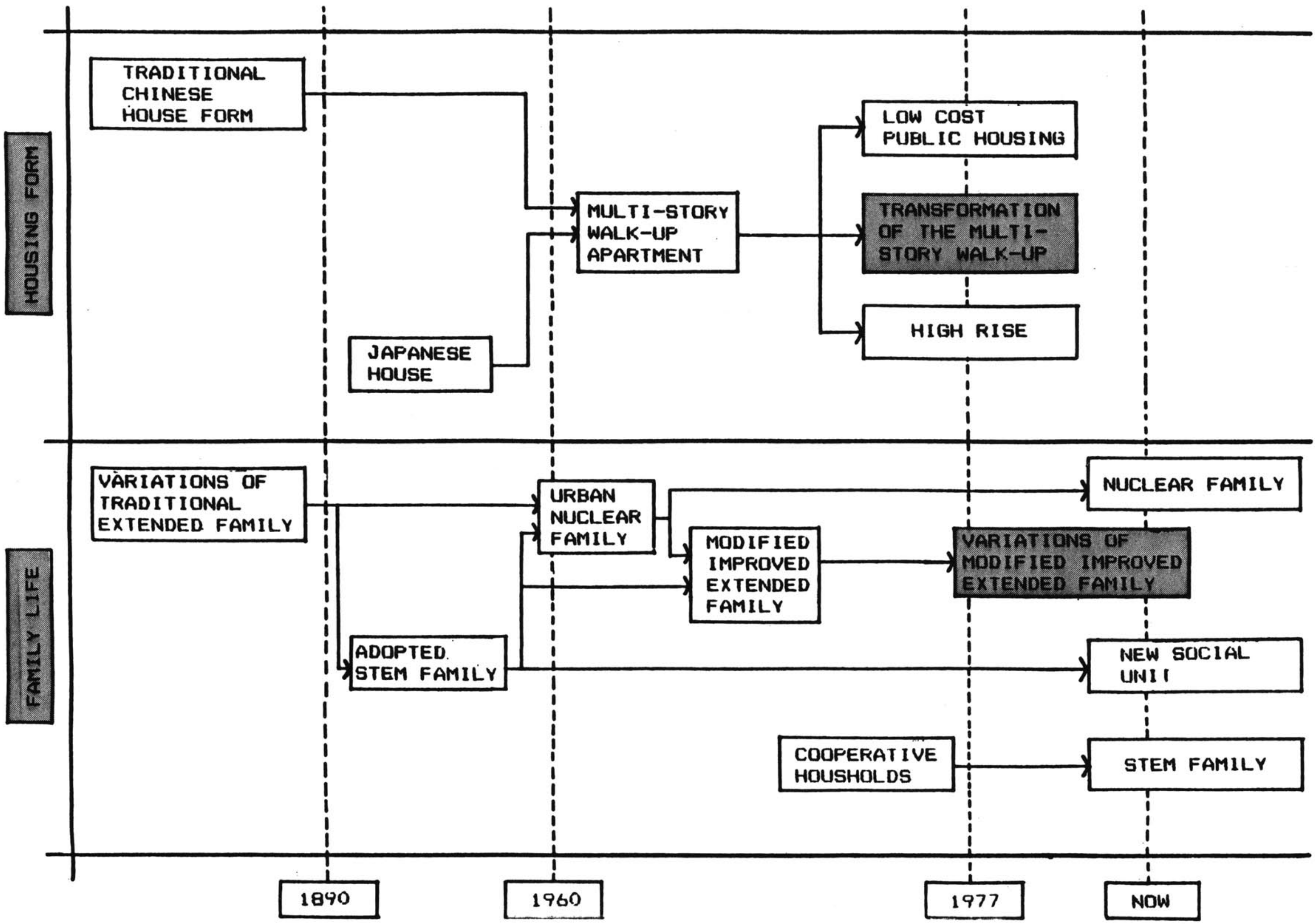
(Fig. 2.1b)

Walk-Up Apartments in Taiwan

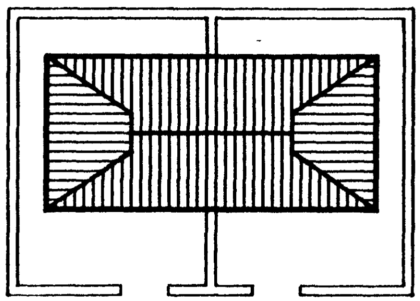
A. CHINESE CULTURAL AND SOCIAL CHANGES

Family life has been changing radically in many industrializing and modernizing countries. In Taiwan, the family patterns have evolved from the extended household to nuclear and independent units. However, it is still a expression of filial piety to live with elderly parents in Taiwan. At present, there is evidence of a persistent need for extended and new family relations, as manifested in a form called "modified-improved extended families". (Fig. 2.2)

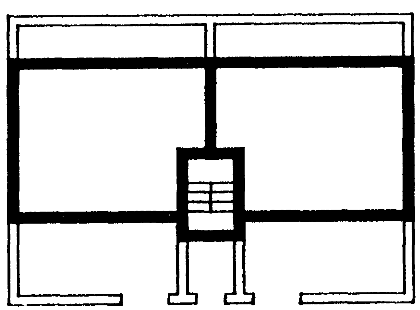
The "modified-improved extended family" includes the vertical and/or horizontal extensions from the nuclear family. Typically, a vertical extension is composed of elderly parent/s and the family of one of their sons or daughters. The family unit includes



(Fig. 2.2) Housing Transformation in Taiwan



(Fig. 2.3a)
Japanese Duplex Houses



(Fig. 2.3b)
Walk-Up Apartments in Taiwan

members of three generations but is separated from the branches and periphery connections. Horizontally, the common form is a joint household maintained by families of brothers. Usually unmarried brothers and/or sisters are also in the household. This specific family type contributes a lot to the formation of the multi-family walk-up apartments in Taiwan.

B. JAPANESE COLONIAL INFLUENCES

In the early stage of this walk-up apartment evolution, most of the new buildings were built on the sites of demolished houses built in the Japanese colonial period. (Fig. 2.3 a, b) These buildings adhered strictly to the building and zoning codes instituted and left behind by the Japanese colonial administration.

A typical Japanese house in Taiwan was a duplex -- two houses sharing a common wall. Generally the house occupied a lot of approximately 100 - 120 ping (325 - 390 m^2). Basically, the new buildings were built right on the top of old foundations with the maximum allowable building coverage of 60% of the lot. So, two apartments might occupy approximately 30 - 40 ping (100 - 130 m^2)

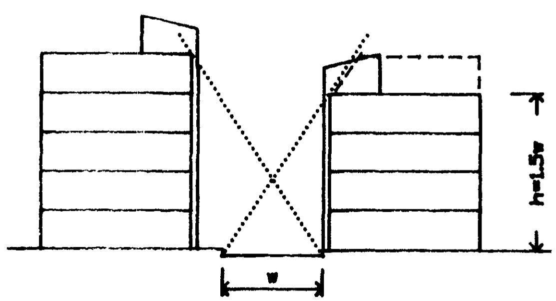
each on one level with a common wall between them.

Given the opportunity of going higher, the building needs a stair well to reach the upper levels. Typically, the staircase is located between the two halves of the building at the front, facing the street.

C. BUILDING CODES AND ZONING REGULATIONS

The building codes rule that 60% of the lot area be the maximum allowable building coverage for residential constructions. But, balconies in the front and in the back of a building are not considered as building coverage. The actual coverage is therefore technically often greater than what the law allows.

The height of the building is also restricted by law to 1.5 times the width of the street in front of the building. Beyond that height, a set back rule dictates that the building must be retreated to the diagonal line drawn from the far side of the street to the near side with the height of 1.5 times the width of the street. (Fig. 2.4) Since most old residential streets are about 8 meters wide, the height limit is four to five stories. Also, five stories is the maximum floor height allowed by codes



(Fig. 2.4) Building-Height Limitation

for buildings without elevators.

Besides code requirements mentioned above, building economics and construction techniques have also contributed to the making of the multi-family walk-up apartments in Taiwan.

D. ECONOMIC AND INDUSTRIAL DEVELOPMENT

In Taiwan, the rapid industrialization has attracted numerous rural workers to immigrate to urban areas. The pressure of immigrants' housing needs led to the brisk increase in the density of residential settings. This swift growth in urban populations also created the demand for vertical construction of many stories. As land got scarcer and more costly, multi-story buildings became both necessary and desirable to meet growing housing demand and development costs.

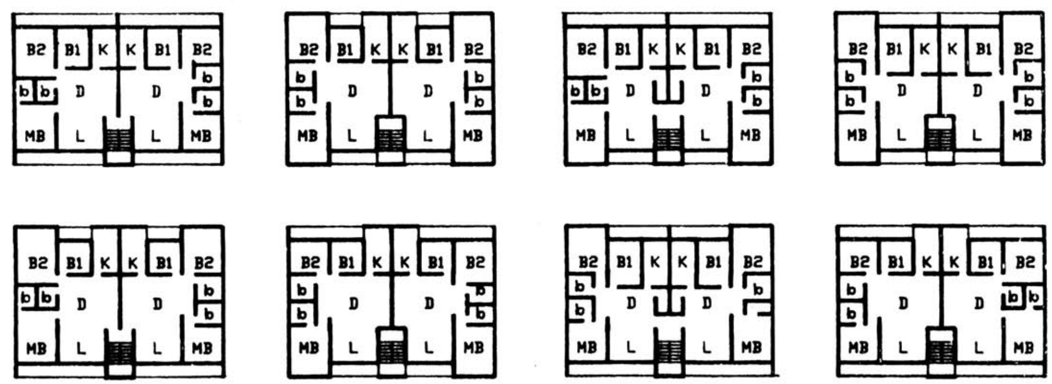
Along with industrialization, it became popular to use concrete construction and brick infill for walls and partitions as innovations in building technology. This has provided the wide-spread and primary means for fast, economical, multi-story housing construction.

(Fig. 2.5a) Typical Plan

E. CONSTRUCTION PROCESS

Because zoning and building regulations are strict, once given a lot size, architects in Taiwan had to come up with a typical plan. It has two units on each floor with approximately 30 - 40 ping (100 - 130 m²) for each unit. (Fig. 2.5 a,b)

Once the plans are drawn up, the project is intensively advertised and usually sold quickly to prospective buyers. Commitments from buyers of individual units are sought prior to actual construction. Since each buyer owns the apartment prior to its constuction, prospective occupants have a chance to decide how it is to be furnished. This gives distinctive qualities to each apartment while the basic plan remains the same.



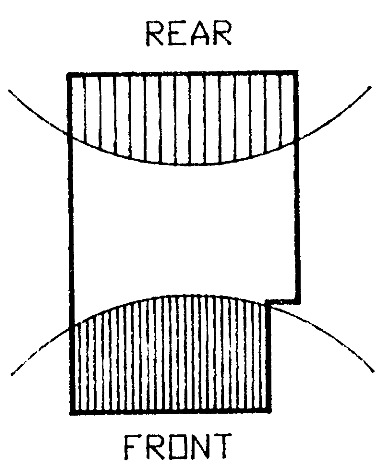
(Fig. 2.5b) Typical Variation

2.2 THE "FORM" OF THIS TYPE

In this recognition process, I limited my observation strictly on the physical phenomenon which can be distinguished as solid -- elements, and void -- spaces. Space and material elements enhance one another; One must imply the other. There is a distinction but no separation.

We can see configurations by distinguishing certain selections of elements and their distributions at the site. We also see how certain configurations indicate the boundaries of spaces and distinguish certain selections as well as distributions of spaces.

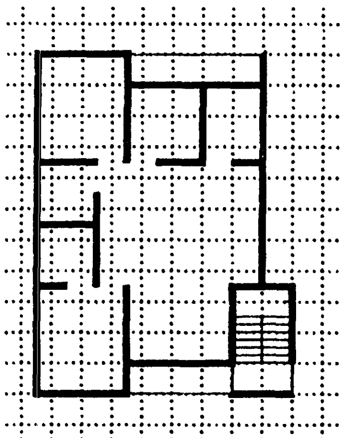
Through observations on the multi-family walk-up apartments in Taiwan, I have extracted certain general conclusions about this specific type. The form of the multi-family walk-up apartments then can be described through our observations of the physical environment as follows:



(Fig. 2.6) Orientation

A. ORIENTATION

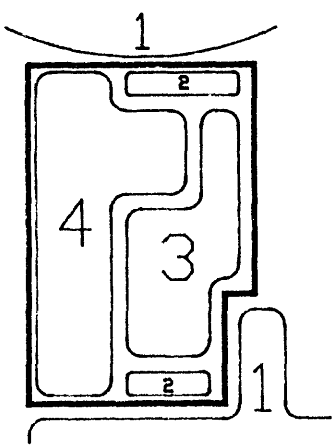
There is a strong sense of orientation with people, they want to easily distinguish spatial directions. There are clear distinctions between the front and the rear of these multi-story duplex row buildings. (Fig. 2.6) People are aware of the importance of specific space locations in the interior. Spaces with more intensive activities tend to put in more significant locations. For instance, living rooms and master bedrooms are always in the front part of the building.



(Fig. 2.7) Rectangle

B. RECTANGLE

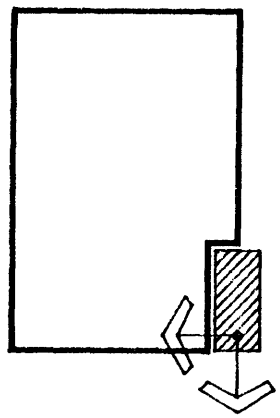
In Chinese, "diagonal" sounds exactly like "evil". Both are prounced as "hsieh". Thus physical configuration and spatial arrangement are preferably laid out at right angles and integrated into a geometrical rectangular grid system. The form of the building therefore neatly comes out with a rectangular shape. (Fig. 2.7)



(Fig. 2.8) Territory

C. TERRITORY

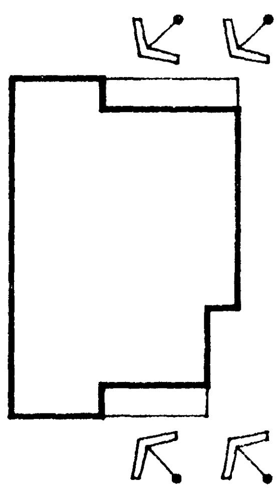
In this type of residential building, the territory is clear and a sequence of privacy is distinguished. The sequence and the territory are as follows: outside (public) --- staircase (semi-public) --- front balcony (semi-private) --- living & dining room (semi-private) --- bedrooms (private) --- kitchen (semi-private) --- back balcony (semi-private) --- outside (public). (Fig. 2.8)



(Fig. 2.9) Access

D. ACCESS

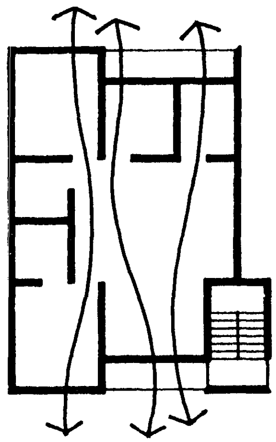
Each dwelling unit has its own main entrance directly to the public open space or to a shared entrance hall. The shared entrance hall enables users to express their identification and the control of their territory. (Fig. 2.9) Balconies are used as transitions between inside and outside activities.



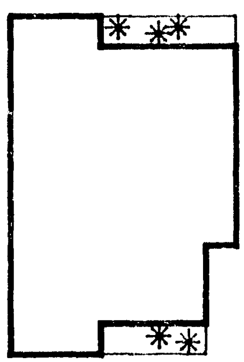
(Fig. 2.10) Sunlight

E. SUNLIGHT

Buildings are preferably north-south oriented for preferable sunlights. There must be direct sunlight to at least one side for every living space (bedroom, living room, kitchen, etc.). Interior window curtains are popularly used to shade the sunlight. Balconies are also preferred as efficient horizontal shading devices for the subtropic climate in Taiwan. (Fig. 2.10)



(Fig. 2.11) Ventilation



(Fig. 2.12) Plainting

F. VENTILATION

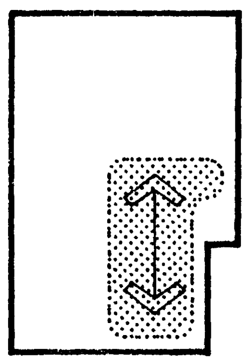
There are at least two openings in every interior space for natural ventilation. (Fig. 2.11) In the kitchen and bathroom, auxiliary mechanical ventilators are installed for their heavy steam and smoke. In the living room and the master bedroom, residents have the option to install air-conditioners into provided openings to deal with the subtropical summer in Taiwan.

G. PLANTING

There are a lot of potted plants in the balconies and outside the window. Residents use these plants to identify and beautify their territories. Shortage of green space in the urban area has increased the use of potted plants too. Steel cases are installed to prevent the flower pots from falling and dropping into the street. (Fig. 2.12)

H. LIVING & DINING

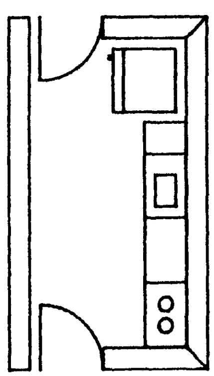
Living and dining rooms are conceived as the center of the whole family activities. They are also a passage from the front to the back of the house. This is a multi-purpose space where a variety of activities, both formal and informal, can take place. These activities include reception, recreation, worship, family chatting and eating together. Quite often an altar for the ancestors and gods is placed in a formal manner against a solid wall facing the entrance. (Fig. 2.13)



(Fig. 2.13) Living & Dining

I. COOKING

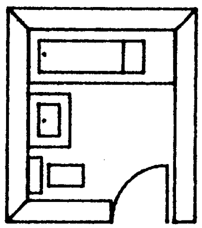
Cooking activities are isolated to the back of the unit because Chinese cooking always brings abundant steam and smoke. In addition to a mechanical ventilator, a kitchen is still directly exposed to the outside for natual ventilation. In the kitchen, there are a sink, a gas stove, a refrigerator, counters and cabinets for storage. The normal size for a kitchen is about 1.8m by 3.3m -- 2.4m by 4.2m. (Fig. 2.14)



(Fig. 2.14) Cooking

J. BATHING

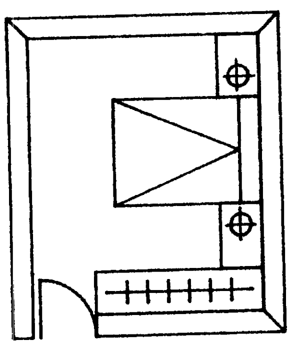
By means of mechanical ventilators, a bathroom can be located in spaces without any direct exposure to the outside. There is at least one bathroom with a bathtub, a sink and a toilet for the whole family with easy access. (Fig. 2.15) The normal size for a bathroom is about 1.5m by 2.4m -- 1.8m by 2.7m. When a bathroom is bigger, residents usually put laundry equipments in it. Generally a second bathroom is preferred to attached to the master bedroom.



(Fig. 2.15) Bathing

K. SLEEPING

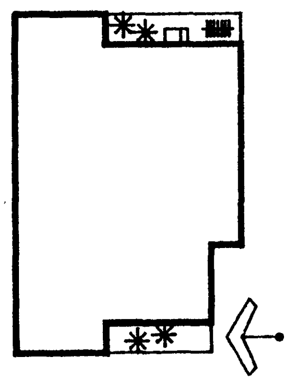
In each bedroom, furniture includes beds, desks, cabinets, and/or a dressing table for women. They function for sleeping, studying, storage, making up, etc. The normal size for a single bedroom is about 2.4m by 3.6m -- 3.6m by 3.6m. The normal size for a double bedroom is about 3.6m by 4.2m -- 4.2m by 4.8m. (Fig. 2.16) A master bedroom is a little larger than the other bedrooms. It is usually in the front part of the dwelling and, as mentioned above, a bathing unit is usually included in it. However a bathing unit either connects with or locates conveniently near the bedrooms that have no bathrooms.



(Fig.2.16) Sleeping

L. BALCONY

Balconies no wider than 1.5 meters are not counted as a part of the building coverage limitation. They provide a sense of



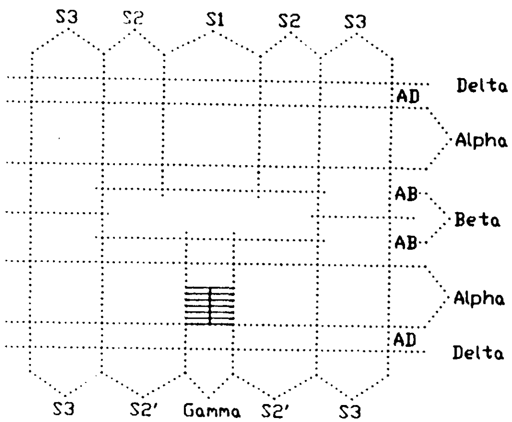
(Fig. 2.17) Balcony

possession of open spaces. The front balcony is normally used as space for transition and space for entrance. Residents and guests can take off shoes and put on slippers here. It is also a space for semi-public use, and a space for planting.

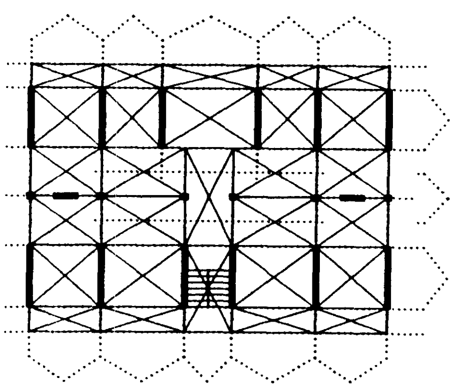
The back balcony is a space of mutiple uses. A washing machine, a gas container, a boiler, and a sink are here. It is also the space to dry clothes in the air, to grow plants, and to store things. (Fig 2.17)

CHAPTER 3

CHAPTER 3 DEVELOPMENT OF THE SYSTEM



(Fig. 3.1a) Saptial System



(Fig. 3.1b) Physical System

A system, in general, is a set of clearly defined elements, plus a description of the relationships among them. Building can be described as a system in which specific elements relate to each other according to specific rules. After observing the physical environment of multi-family walk-up apartments in Taiwan, we can generate systematic rules for the design of this specific type of housing. (Fig. 3.1a,b)

With this concept, the building can be regarded as a system of components, ordered according to certain rules -- a system in which spaces are the system's components, and the relationship between those spaces conforms to certain rules.

Since rules of the system are relative positions of elements in space, the S.A.R. methods offer ways to solve the coordination and evaluation problems in design by use of the system in a shared spatial framework -- a grid of modular and zone distribution. They provide the means for participants* to coordinate and communicate individual decisions easier.

* PARTICIPANTS

The participants of the multi-family walk-up apartments in Taiwan are architects, developers, and users who are involved in the decision-making process.

SPECIAL PURPOSE SPACES

R	Specific Purpose Room
B1	Single Bedroom
B2	Double Bedroom
MB	Master Bedroom
K	Kitchen
K1	Kitchenette
KD	Kitchen + Dining
E	Entrance

GENERAL PURPOSE SPACES

L	Living Room
D	Dining Room
LD	Living + Dining
F	Family Room

SERVICE SPACES

b	Bathroom
b1	Toilet + Sink
b2	Bathroom + Laundry
St	Storage
S	Stairs

(Fig. 3.2)

3.1 IDENTIFICATION OF THE ELEMENTS

All the spatial functions can be divided into three groups -- special purpose spaces, general purpose spaces and service spaces.

(1) Special purpose spaces:

Are intended for particular activities over a certain length of time. They include bedrooms, kitchens, studies, etc. The maximum and minimum size of which can be determined on the basis of an analysis of their functions. (Fig. 3.2)

(2) General purpose spaces:

Are the largest single space in the dwelling and can have a wide variety of arrangements to accommondate different kinds of activities for the whole family. Such space cannot be determined in advance.

(3) Service spaces:

Are not meant for long term occupation, but are present in the dwelling for short term, specific activities. They include storages, stairs, and bathrooms. Both the size and layout of such spaces can also be determined on the basis of an analysis of their functions.

3.2 POSITION RULES OF THE ELEMENTS

Spaces can be placed in a zone/margin system according to certain conventions among a group of people -- the participants. To determine how spaces can be located in a zone distribution, zones and margins are categorized according to which particular spaces are situated and/or defind them.

The zones and margins in a zone distribution can be defined as follows:

(a) An alpha (α) zone is an internal area, intended for private use, and is adjacent to an external wall.

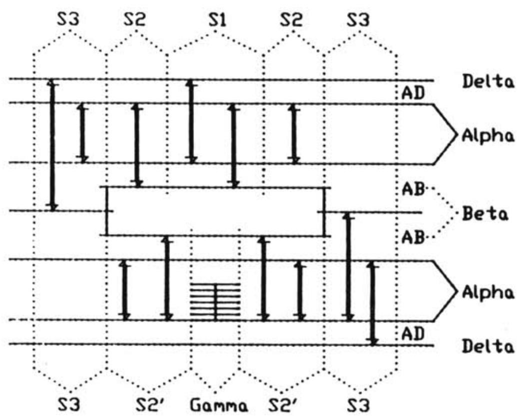
(b) A beta (β) zone is an internal area, intended for private use, but is not adjacent to an external wall.

(c) A delta (δ) zone is an external area, intended for private use.

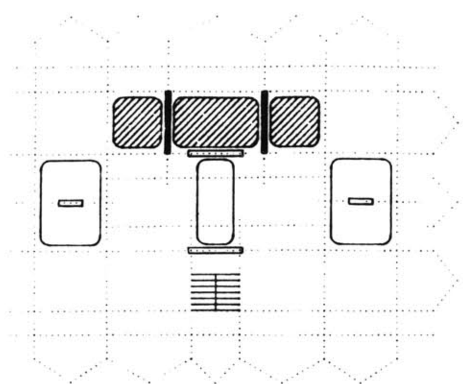
(d) A gamma (γ) zone can be internal or external but is intended for public use.

(e) A margin is an area between two zones, with the charac teristics of both zones and taking its name from them.

(f) A sector is part of a zone and its adjoining margins that is



(Fig. 3.3a) Special Purpose Space



(Fig. 3.3b) Kitchen Position

unobstructed and can be planned freely.

Now we can investigate the relationships between their location and the zone distribution as following:

(a) Special purpose spaces:

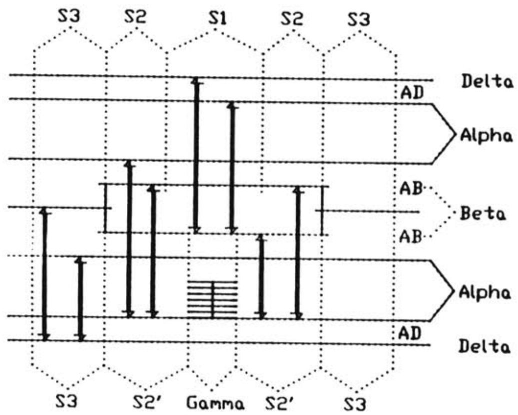
Such spaces always end in two consecutive margins. The minimum depth of these spaces is the width of the zone. The maximum depth is the width of the zone plus two adjoining margins. (Fig. 3.3a) These spaces are adjacent to the facade, in the alpha zone. The position rule for a kitchen will also restricted by the location of the duct. (Fig. 3.3b)

(b) General prupose spaces:

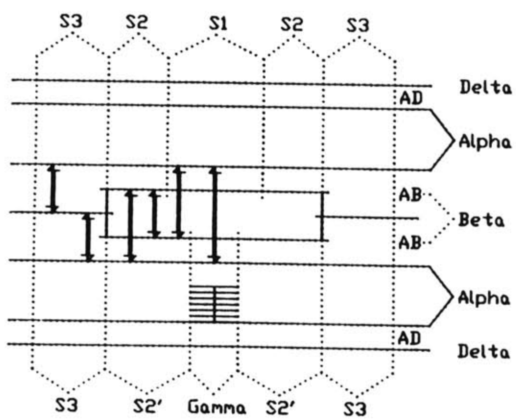
Such spaces may overlap one or more zones and end in a margin. Since such spaces are adjacent to the facade and to special purpose spaces, they often occupy the alpha (α) zone or both alpha (α) and beta (β) zones. (Fig. 3.4) Dining spaces are often located in the beta (β) zone at the center of the dwelling.

(c) Service spaces:

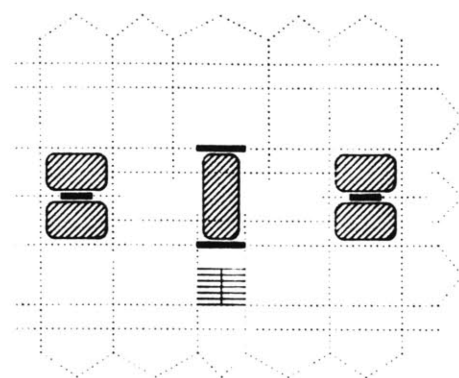
Such spaces are not necessarily adjacent to a facade. They are usually small and related to a special purpose space. It is often possible to locate them in the alpha beta ($\alpha\beta$) margin or the beta (β) zone. (Fig. 3.5a) The location of a bathroom is also restricted by the location of the sanitary duct. (Fig. 3.5b)



(Fig. 3.4) General Purpose Space



(Fig. 3.5b) Bathroom Position



(Fig. 3.5a) Service Space

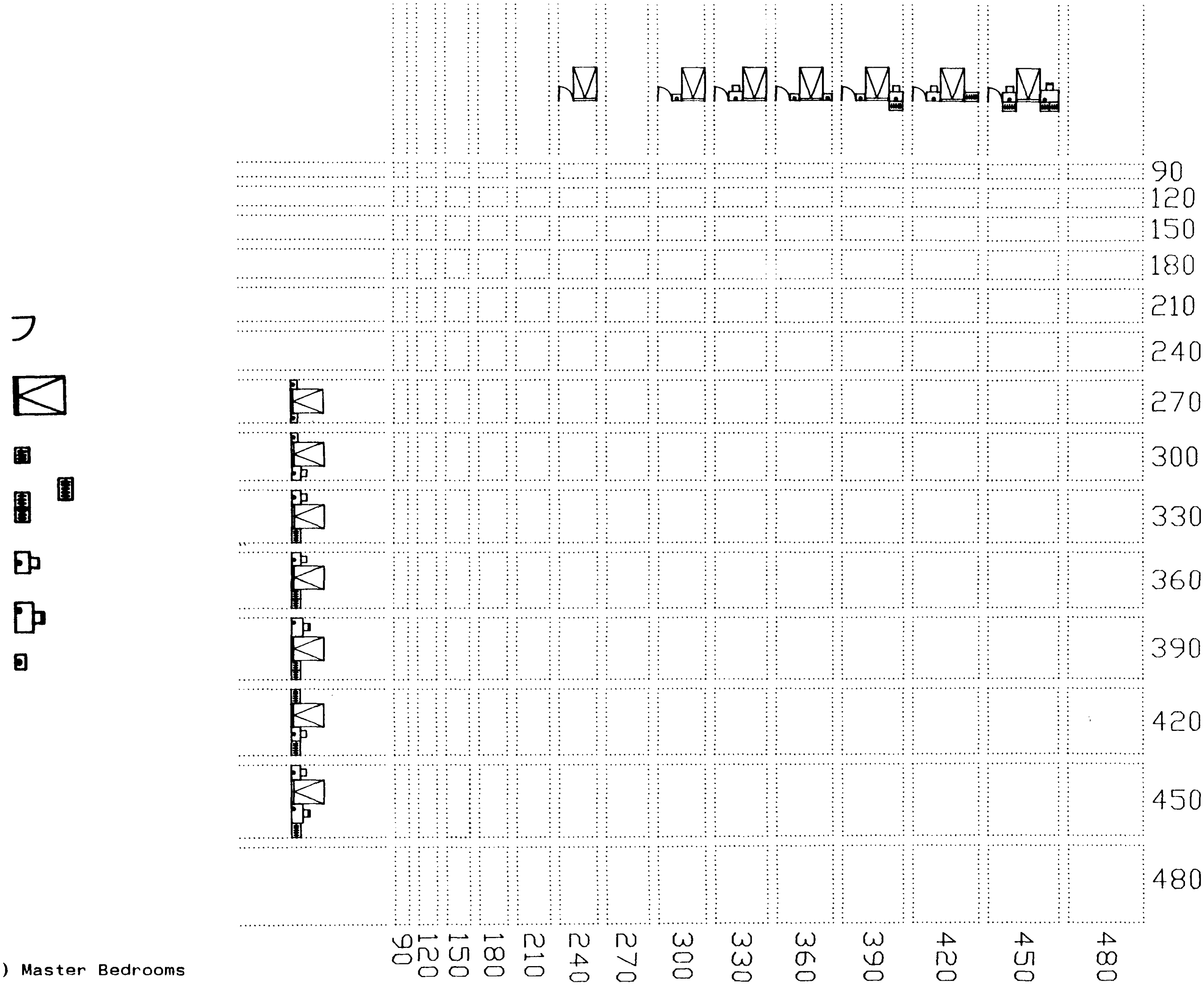
3.3 DIMENSIONS OF THE ELEMENTS

The proportions of a zone distribution (zones, margins, and sectors) are usually based on the preferred maximum and minimum size of the spaces in a dwelling. Location of a space in a zone distribution implies certain maximum and minimum sizes.

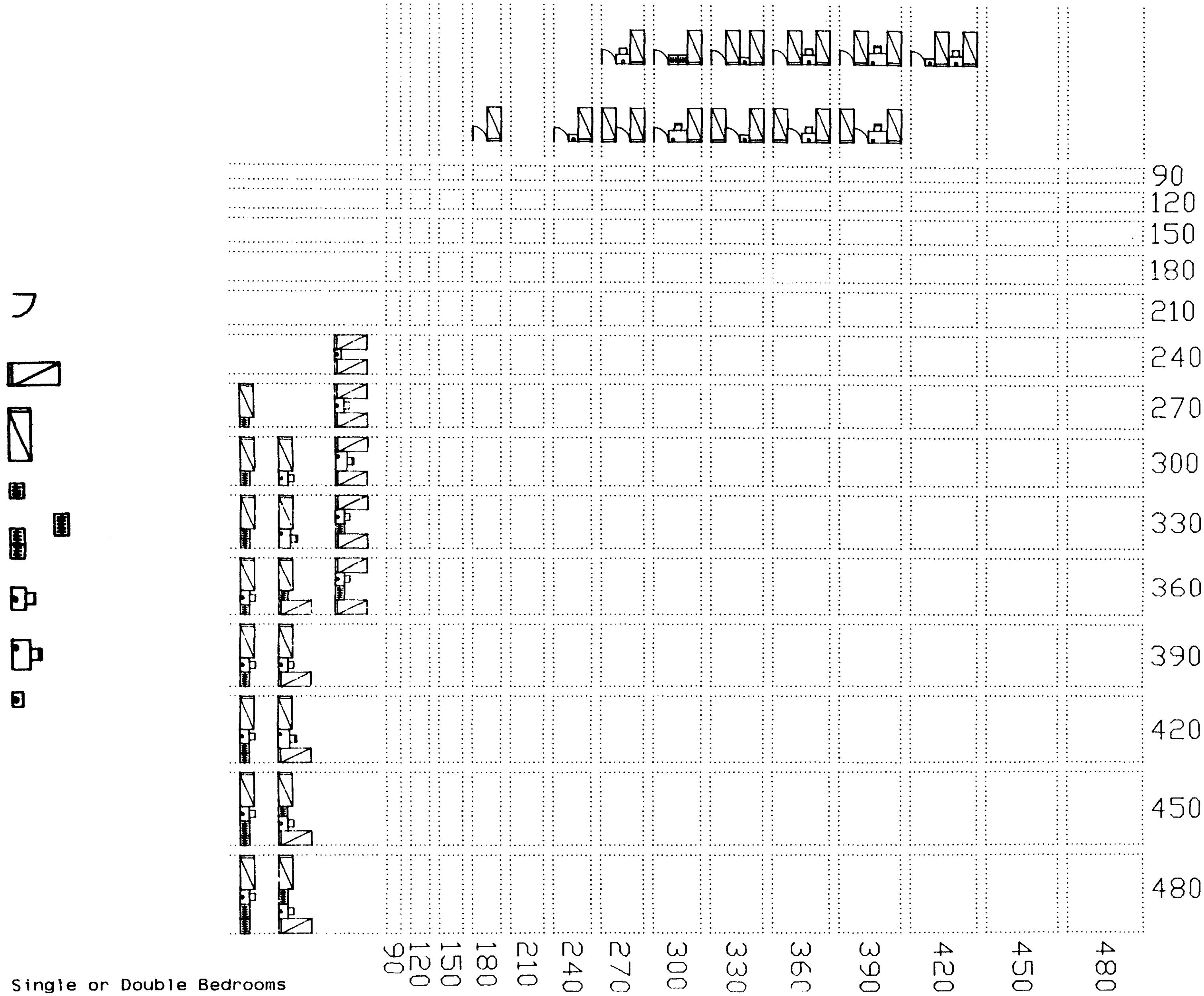
The relationships between special purpose spaces and their specific uses can be clarified with the aid of a space and function analysis chart. With the analysis of their functions, the desired dimension range of spaces can then be determined. (Fig. 3.6 a,b,c,d)

The relationship between a service space and its function can also be clarified with the aid of a chart. On the basis of analyzing their functions, both the sizes and layouts of such service spaces can be determinated in advance. (Fig. 3.7)

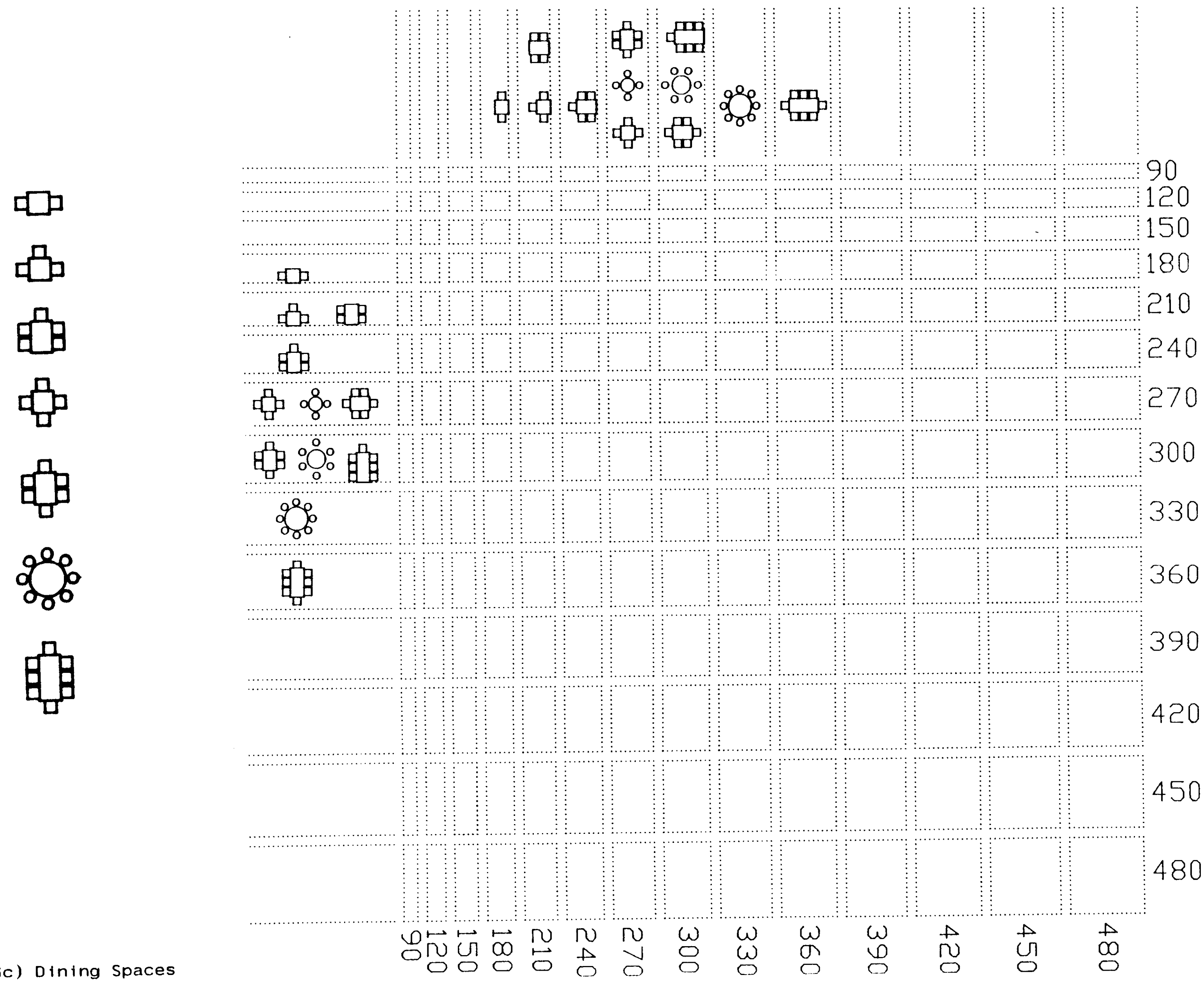
The exact space dimensions (that are chosen ina specific plan) will depend on needs and resources of the occupants. Without specific knowledge about the occupants, it is both impossible and unnecessary for architects to decide the exact dimensions. Though we can not decide the exact dimensions with the analysis



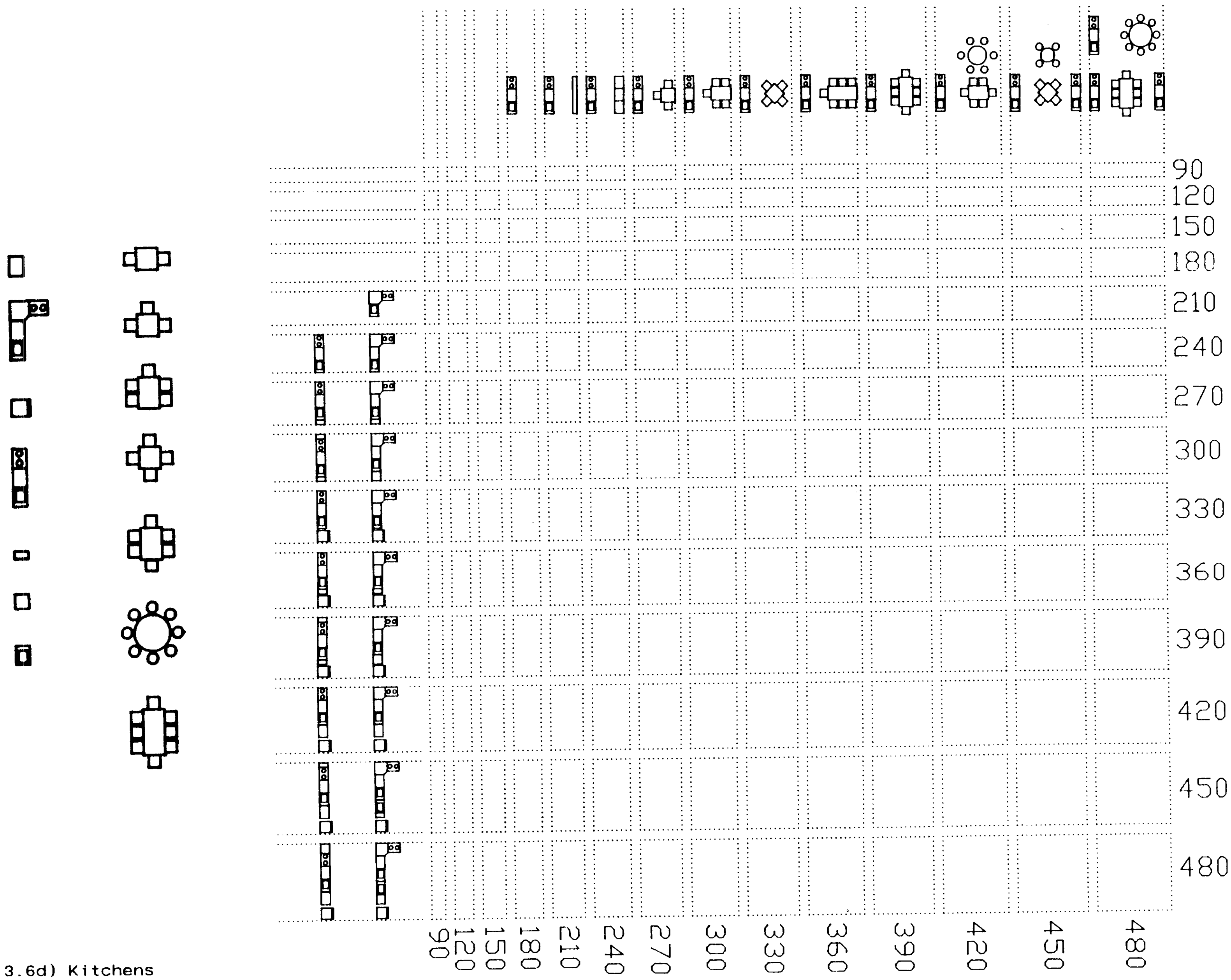
(Fig. 3.6a) Master Bedrooms



(Fig. 3.6b) Single or Double Bedrooms

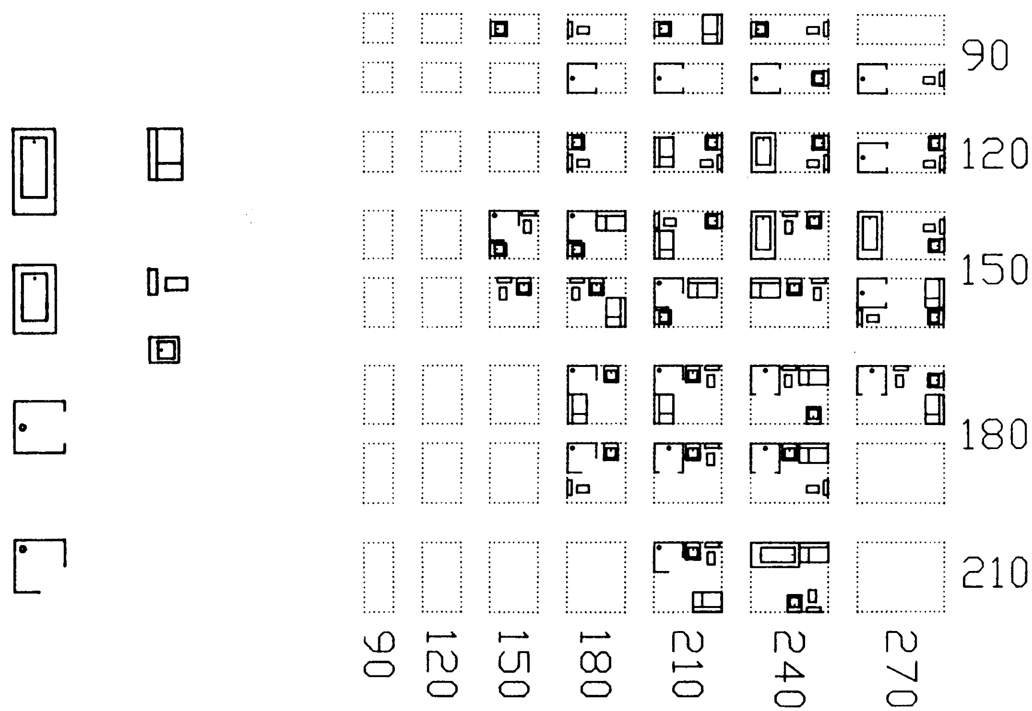


(Fig. 3.6c) Dining Spaces

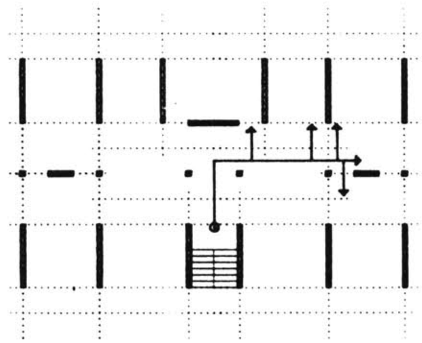


(Fig. 3.6d) Kitchens

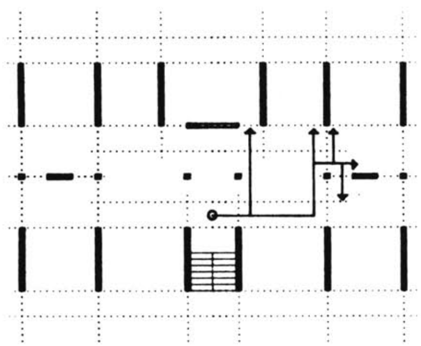
above, we have a better idea about the possible dimensions of these spaces from the analyses. We can make sure that the dimensions offered by each zone, margin, and sector are within certain desirable range. We then let occupants from their specific contexts make their own decisions. Also, with the help of space and function analysis, these people may make better decisions.



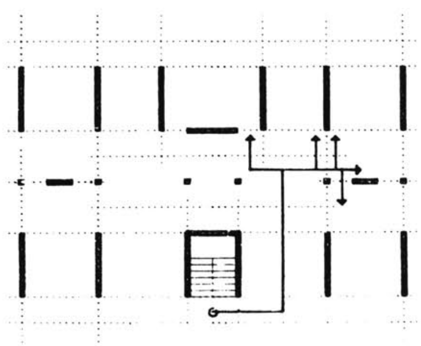
(Fig. 3.7) Bathrooms



(Fig. 3.8a)



(Fig. 3.8b)



(Fig. 3.8c)

3.4 STAIRS AND DUCTS

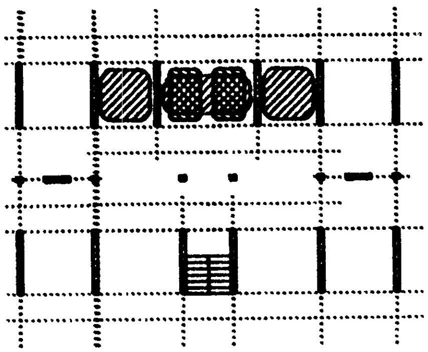
The placement of the staircase will determine the location of the entry door to each apartment unit. In the support system for multi-family walk-up apartments in Taiwan, I propose two alternative placements for the staircase.

One alternative is to put the entry door at the far end of the staircase away from the street. This entry locates at the lateral center of the apartment. The door either straightly faces the stairs or locates on the side of the stair landing. Functionally, this arrangement makes sense since the circulation from the entry to all the other part of the apartment is shortest. (Fig. 3.8 a,b)

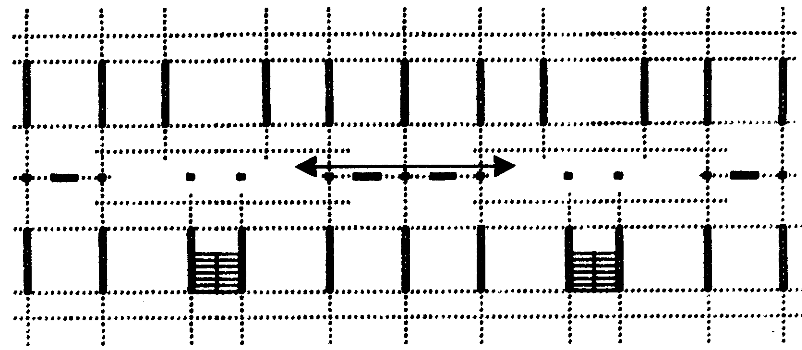
The second alternative is to place the entry door in the front of the building. The method of entering the dwelling unit is through a balcony in the front of the apartment which links with the living room directly. (Fig. 3.8 c) We pass through an inner staircase, get into an open balcony, and then reach the living room. This flow is remarkably similar to the sequence in a traditional Chinese court-yard house.

The location and placement of ducts is also an important aspect of a support design. They determine possible locations of bathrooms and kitchens as well as the capacity of the space that the support structure can possess.

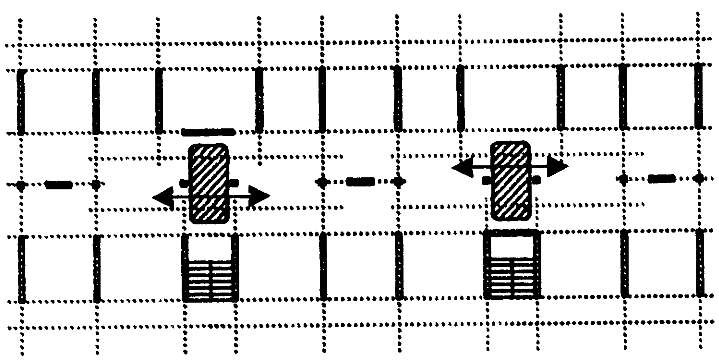
In the support design for the multi-family walk-up apartments in Taiwan, we propose two separate ducts for kitchen facilities in a duplex unit. (Fig. 3.9 a) Thus we may have more flexibility in the location and size of the kitchens. We also propose an auxiliary duct in the center of the duplex unit, either in the front or in the rear of the central location. (Fig. 3.9 b) This extra duct provides a chance to put bathing facilities or an informal kitchen in the back of the staircase. We also turn the ducts horizontal to connect the spaces on both sides of a duplex unit or spaces between units. (Fig. 3.9 c,d) Thus we may have more flexibility in sector group organizations.



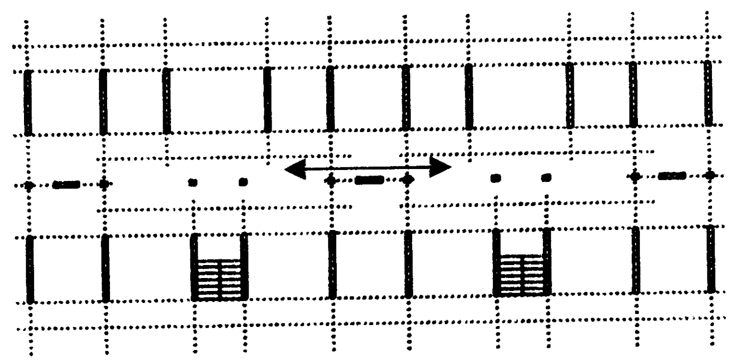
(Fig. 3.9a) Ducts for kitchens



(Fig. 3.9c) Lateral Ducts for Connecting Duplex Units



(Fig. 3.9b) Auxiliary Ducts in the Center of a Duplex Unit



(Fig. 3.9d) Lateral Ducts for Connecting Duplex Units

3.5 PARTY-WALLS AND SECTOR GROUPS

In the proposed support systems for the multi-family walk-up apartments in Taiwan, there are two alternatives in staircase placement. (Fig. 3.10). Besides that, there are two alternatives in connecting duplex units. (Fig. 3.11) Combining both, there are a total of four alternative systems in the zone and sector distribution principles proposed for the multi-family walk-up apartments in Taiwan. (Fig. 3.12)

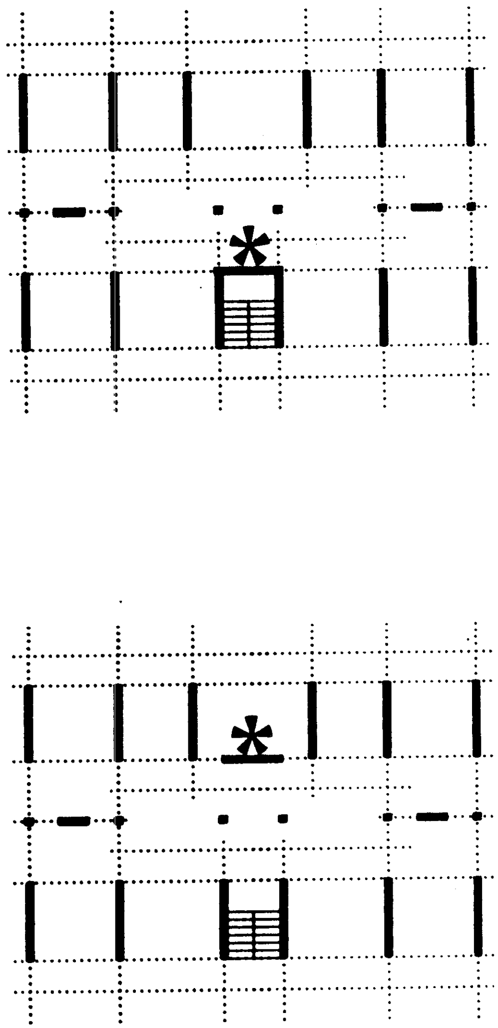
A dwelling in a support structure can be seen as a combination of inter-connecting sectors -- sector groups. The criteria for a sector group to form a dwelling unit are as below:

(a) There are ducts for kitchen facilities, either a formal kitchen or an informal kitchenette.

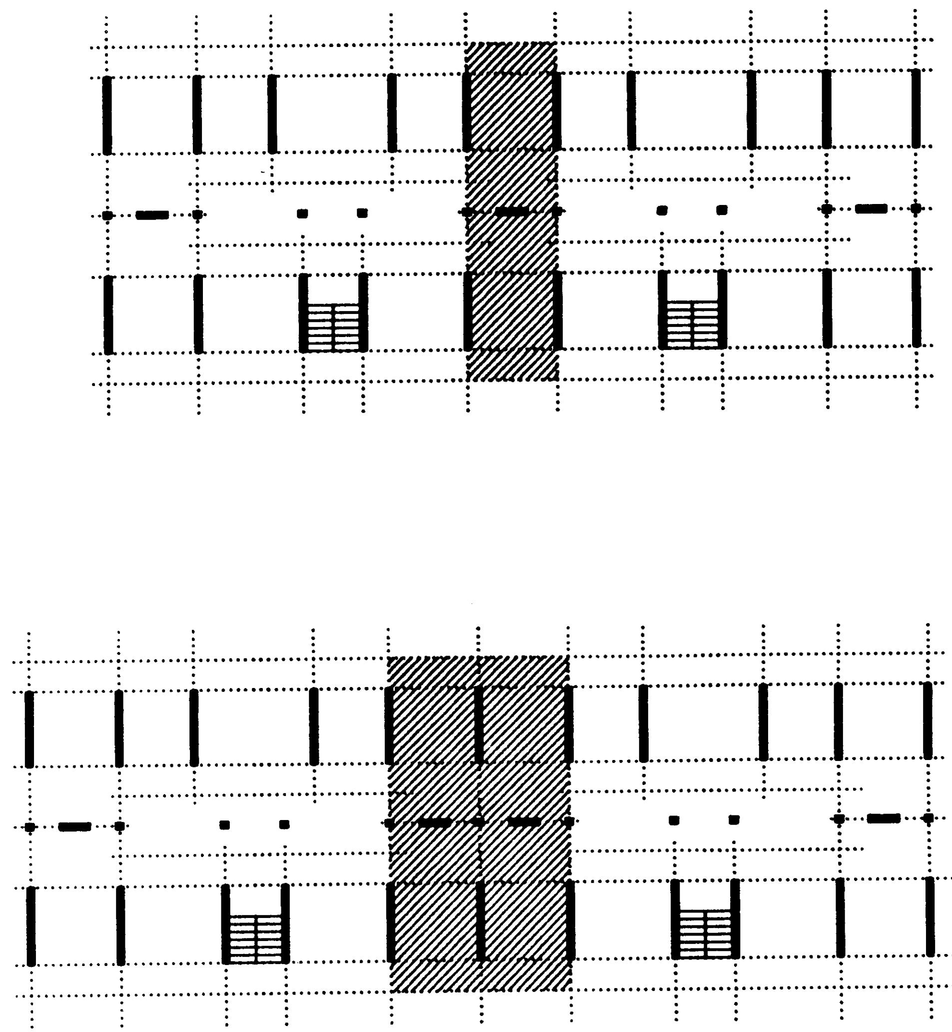
(b) There are ducts for bathroom facilities. The number of bathrooms should be according to the size the family.

(c) Each unit should be accessible from the vertical circulation -- staircase.

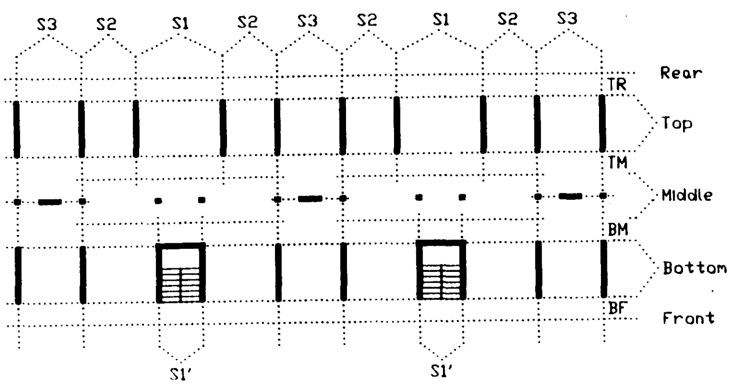
(d) All the spaces within a sector group should be connected and accessible from any part of the sector group.



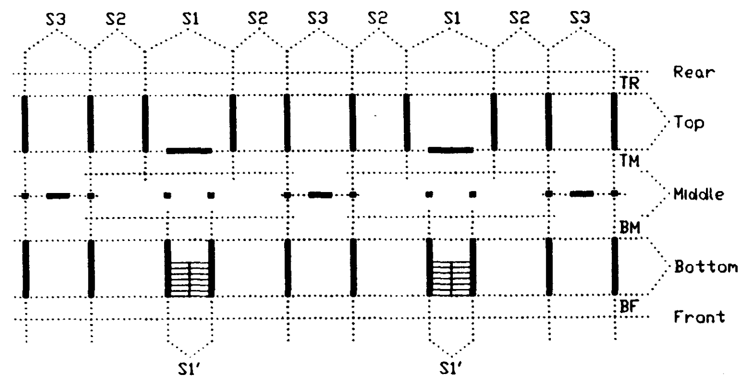
(Fig. 3.10) Stair-Case Placement Alternatives



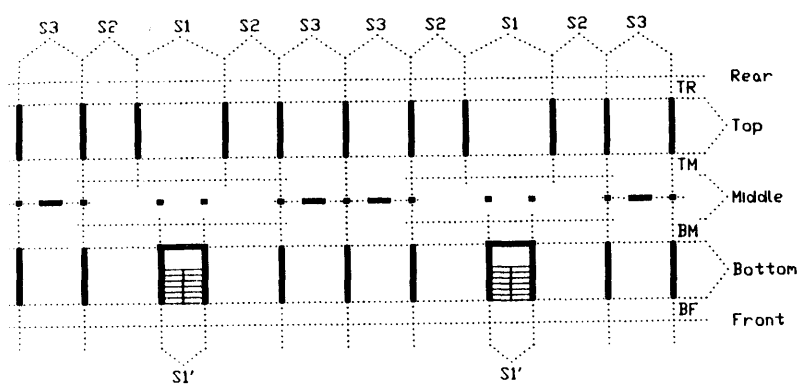
(Fig. 3.11) Unit Connecting Alternatives



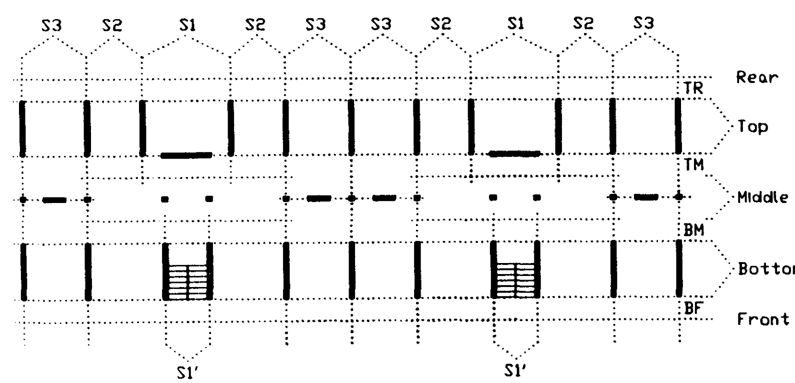
Alternative A



Alternative B



Alternative C



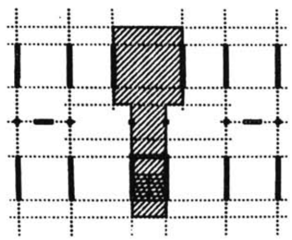
Alternative D

(Fig. 3.12) Four Support Alternatives

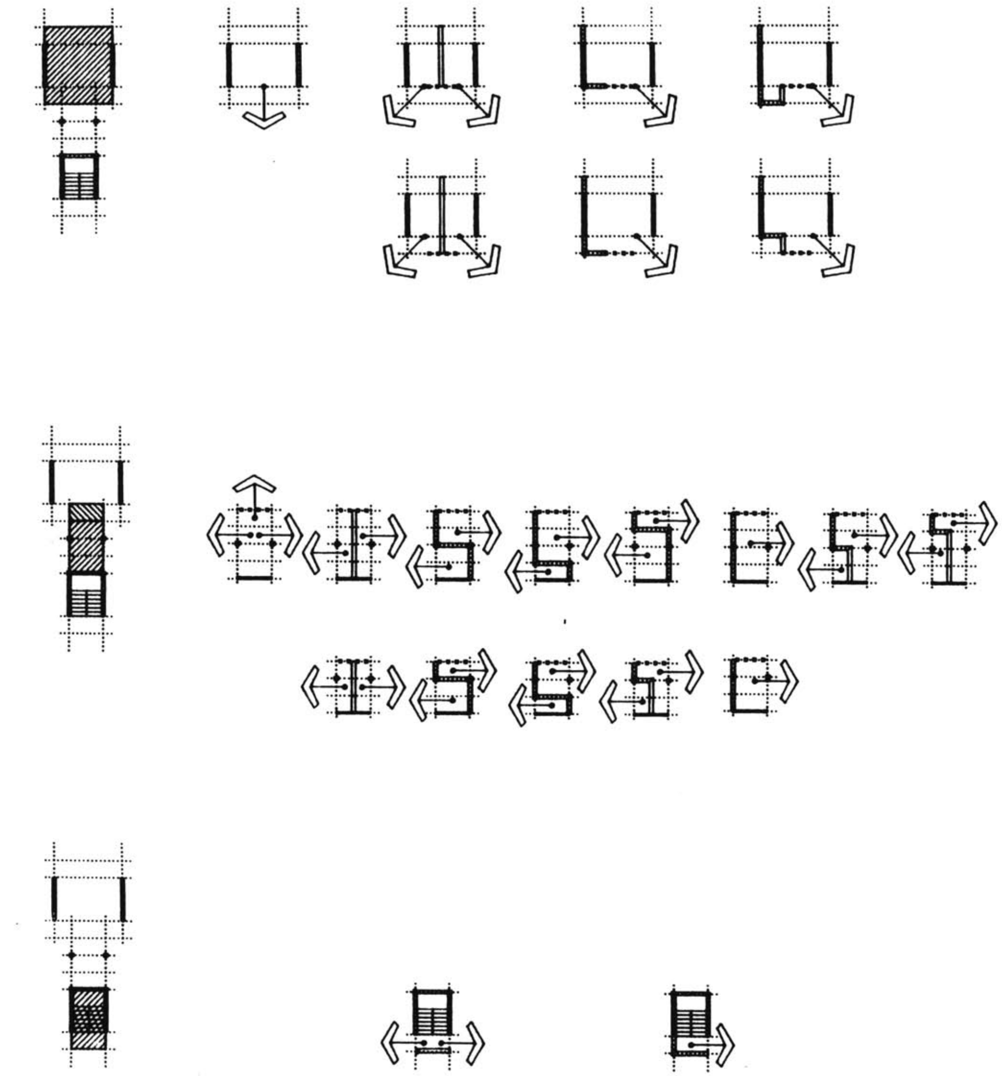
(e) A sector group without adjacency to a facade is not considered a dwelling unit.

Between different sector groups, party-walls separate the dwelling units and define the territories. In the proposed support systems, there are some accompanying rules restrict the possible positions of the party-walls. Looking more closely at the spaces of the proposed systems, we may have a better idea about where these party-walls may be located. (Fig. 3.13 a,b,c,d,e)

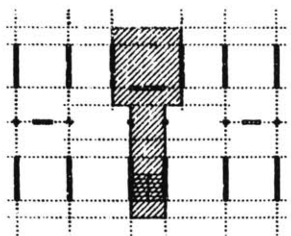
People with different needs and resources then may decide the desired sector groups within the system. They make these decisions according to their specific contexts and agreements with their neighbors. In the proposed support systems for the multi-family walk-up apartments in Taiwan, possible sizes and layouts vary in a great number in sector group organizations. (Fig. 3.14)



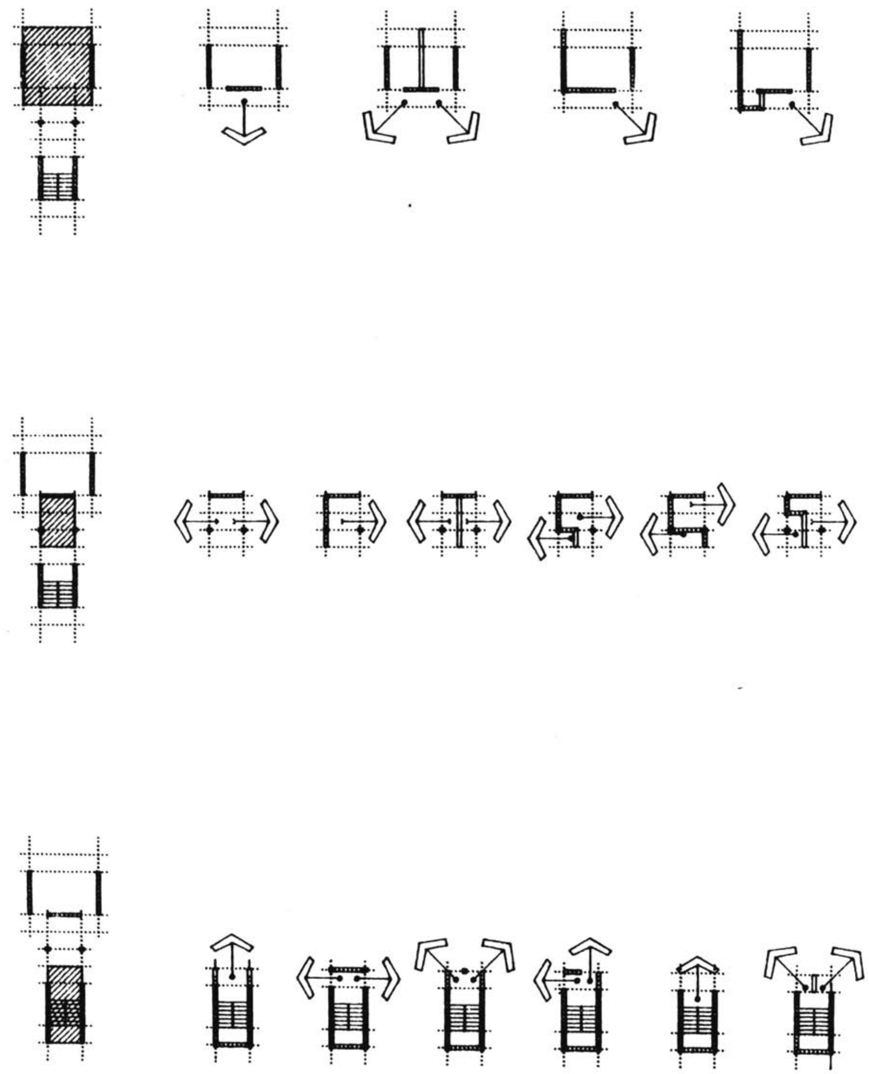
Alternative AC



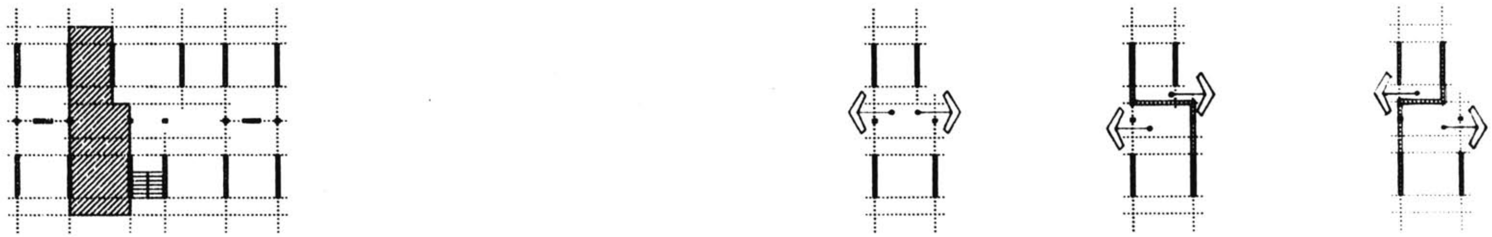
(Fig. 3.13a) Party-Wall Positions



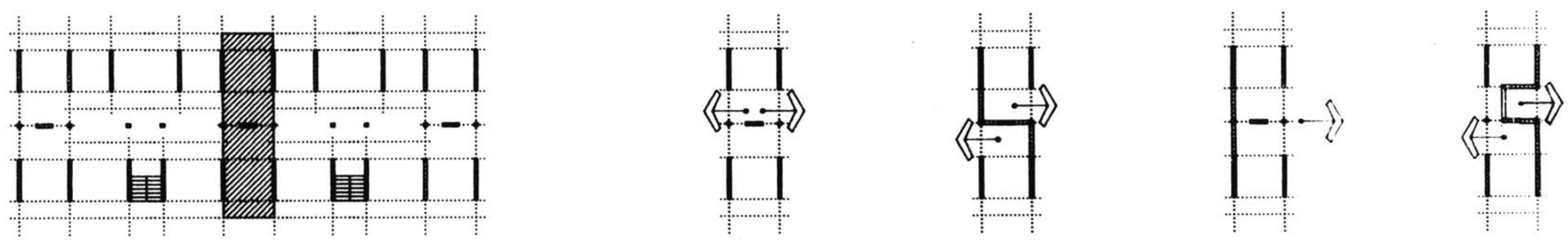
Alternative BD



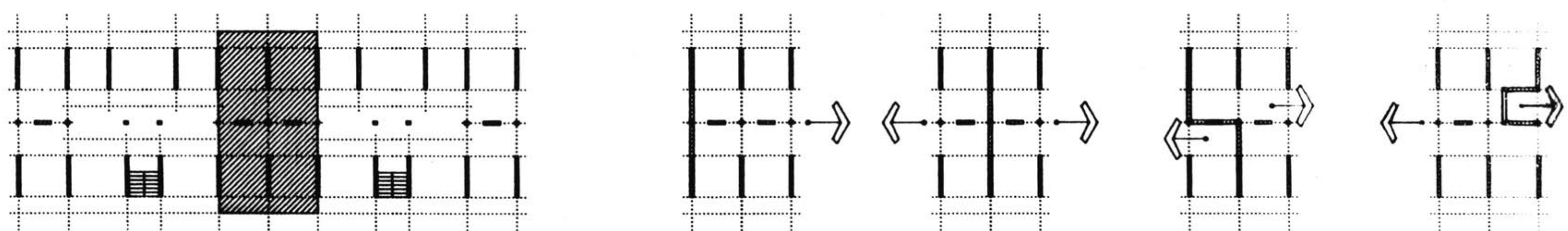
(Fig. 3.13b) Party-Wall Positions



Alternative ABCD

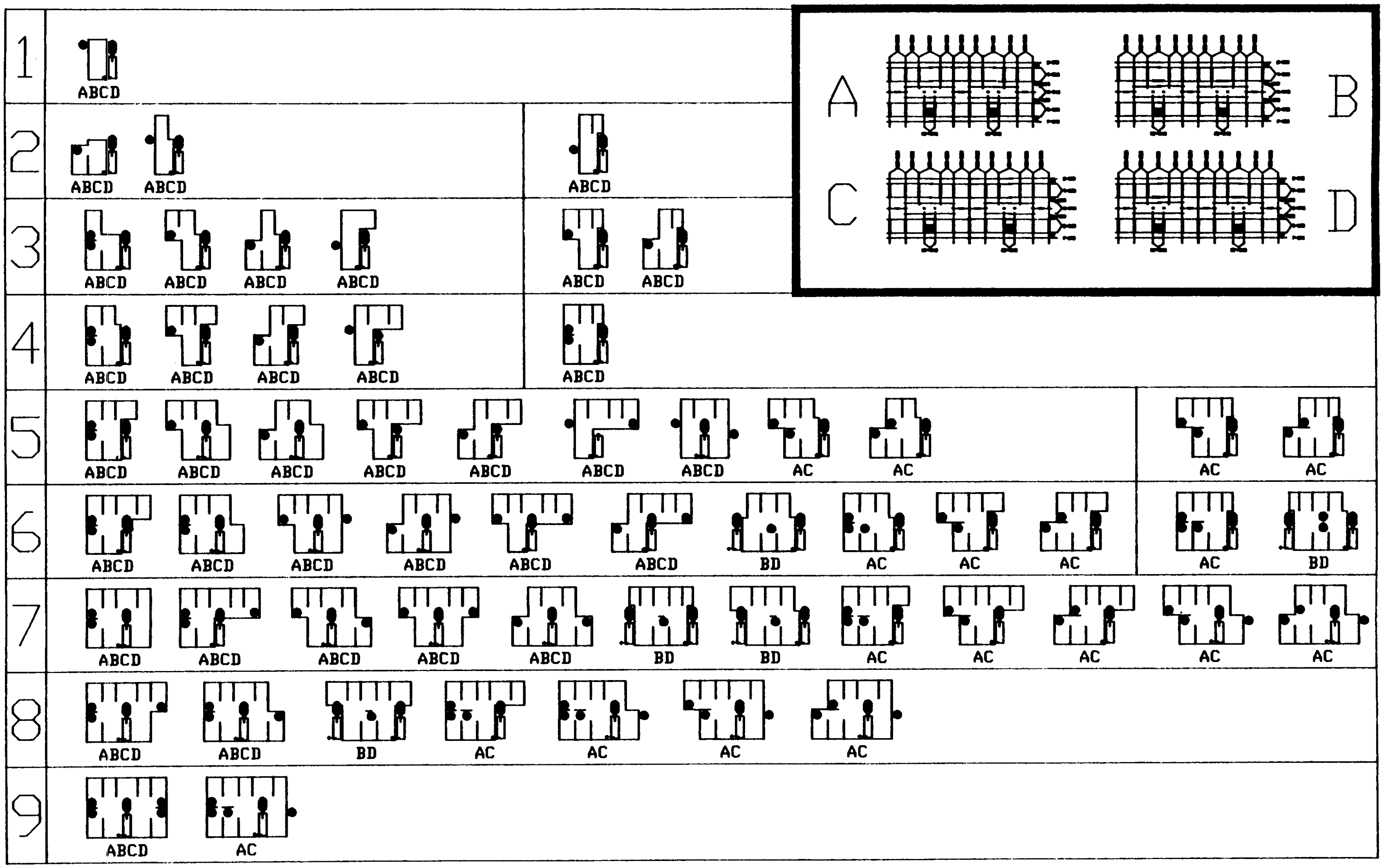


Alternative AB



Alternative CD

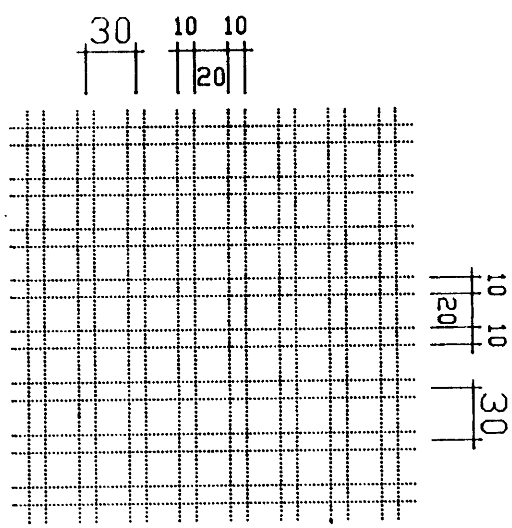
(Fig. 3.13c) Party-Wall positions



(Fig. 3.14) Possible Sector Groups

CHAPTER 4

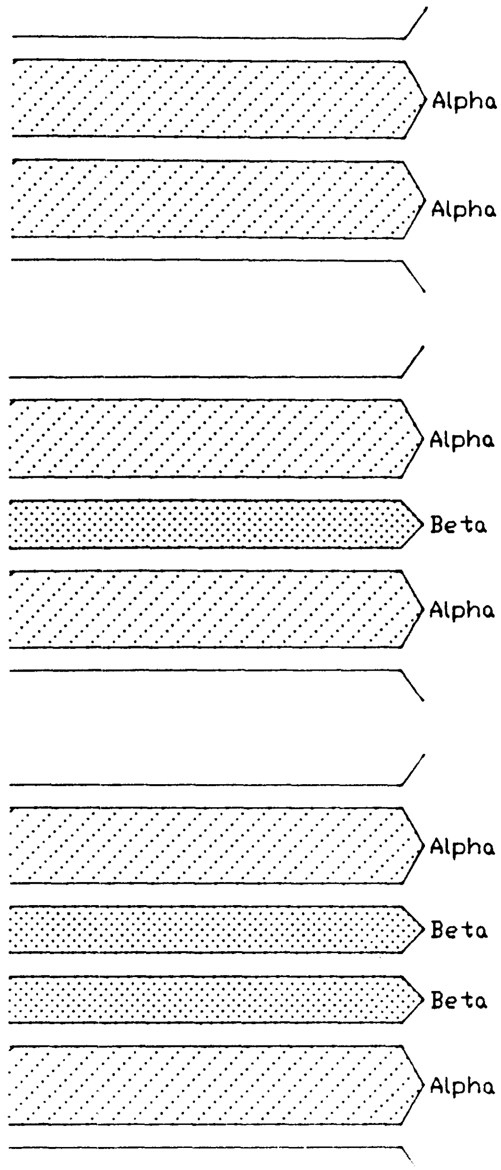
CHAPTER 4 USING THE SYSTEM FOR A DYNAMIC DWELLING DESIGN



(Fig. 4.1) 30 cm Tartan Grid Module

In a dynamic dwelling design, several participants are involved in the decision making process, such as architects, developers, and users. These participants can use the system to reach coordinated decisions. By using a system in the design process, participants can make decisions independently either simultaneously or sequentially in a coordinated way. Moreover, the participants can make decisions incrementally and each decision leaves a number of options to be dealt with at a later stage. To solve the dimensional coordination problem, the S.A.R. method uses a tartan grid plus a set of conventions as modular coordination with a 30cm module to regulate the relative positions of components in a neutral, fixed spatial framework. (Fig. 4.1)

Another problem in design is the issue of evaluation. It rises whenever one wants to measure architectural decisions regarding to the usefulness of the layouts generated. To evaluate a dynamic dwelling design, one has to examine whether the support structure can accommodate the preferred layout alternatives which satisfy the criteria for desired dwelling quality. Therefore, in the evaluation process, matters of quality must be made explicit in terms of standards and norms. The standards and norms are



(Fig. 4.2) Zoning Concept

understood and agreed upon as a system by all the participants in the dynamic dwelling design process. To achieve this, the S.A.R. method introduces a "zoning" concept to divide a dwelling into zones. (Fig. 4.2) Any dwelling can be treated with this concept. And a dwelling type is recognized by a particular combination of zones. The zones contain information on locations and dimensions of spaces.

To evaluate a support stucture of the dynamic dwelling design for multi-family walk-up apartments in Taiwan, at least two issues need to be investigated. First, the design of the support must be judged by the quality of the dwellings that it makes possible. To make such a judgement, the term "good dwelling" for this specific type of housing must be defined. The standards for a "good" dwelling must be set up in a way that they can be used to test layout alternatives. This means that these standards should contain information for participants to judge whether the layout conforms to the definition of a "good" dwelling.

Secondly, it must be possible to proceed with the developments of layout variations. The layout variations not only should conform to those predetermined standards but also should be accommodated in the support structure evaluated. Therefore, the support system proposed is set up to contain information about locations and dimensions of spaces by means of the zoning concept. We now may test whether the support structure can accommodate the desired layout alternatives or not. If it shows that the support structure holds a large variety of "good" dwellings, we may say that it is a "good" support.

In the process of evaluating a support structure of the dynamic dwelling design, we can separate the task into two aspects -- norm-setting and operating.

4.1 NORM-SETTING

The evaluation of a support design is to check whether the preferred layout alternatives, which satisfy the criteria for "good dwellings", can be accommodated by the support structure. Thus the problem of evaluation can be seen as a problem concerning the relationships between two space systems. One system is the space system for the support structure. And the other is the space system for "good dwellings". To evaluate a support, we want to find out what variations of the space system for "good dwellings" can be made in the system for support structure.

Each variation of the system for support structure provides a site for a number of variations of the system for good dwellings. Each support variation must be judged according to how good a site it provides. Everything else equal, the better support for the dynamic dwelling design is the one which can accommodate more variations of the system for good dwellings.

Regardless of the specific contexts of people's needs and resources, the systems developed in Chapter Three are not complete ones yet. They are just principles in the dynamic dwelling design for the multi-family walk-up apartments in Taiwan. As long as participants in the design are given the specific contexts, programs, or requirements from people with resources and needs, they can set up both space systems as norms for design with ease.

A. STANDARDS OF FUNCTION

To set up the criteria for "good" dwellings, one must define the relations between functions and spaces. To do this, it is essential to realize the consequences that the program has on the furniture layouts and sizes of spaces. This formalized systematic analysis on spaces and functions will give the participants a lot of orderly and clear information about the size, shapes, and possible layouts of each space. Charts such as Fig. 3.6 and 3.7 make it easier to visualize the possible layouts and consequent sizes and shapes of each function.

These analyses document the intention of the participants' decisions within specific contexts. They also indicate what standards have been used. The standards reflect certain value systems used in design. For each function, requirements are given for the spaces that may hold that function. Each function is a set of spaces. The possible layouts for each function of different lengths and widths in space reflect certain standards which are shared by participants in design.

B. SUPPORT PRINCIPLES

There are four support system alternatives developed in Chapter Three for the dynamic dwelling design of multi-family walk-up apartments in Taiwan. Regardless of the specific contexts used in design, they are just support principles, not complete systems yet. In these support principles, there are only distributions of zones, margins, and sectors. The dimensions of them will be determined later. (Fig. 3.12)

In the dynamic dwelling design process, we have to evaluate the support structure by checking whether the preferred layout variants are accommodated in the support structure. Therefore, we have to choose one support alternative from the four according to the specific contexts we are working with. And then we can evaluate each. For each support alternative, there are certain characteristics composed by it and which can be used as references to choose from.

The zone distribution of each support system provides a spatial context for space elements. It also describes the spatial relationships between zones. In the meantime, the positions and placements of the stairs and ducts are different in each support system. Hence, the position rules for the space elements are also different. These all contribute to the references to choose one of these support system alternatives to evaluate later.

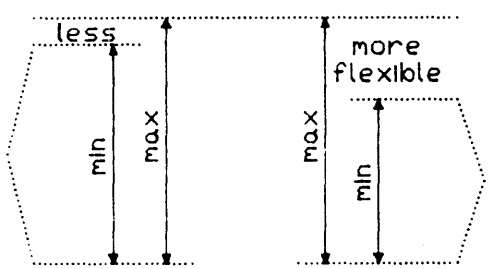
C. DIMENSIONS OF ZONES/SECTORS

With the choice of a support principle from the proposed alternatives, the distribution of zones, margins, and sectors are hereby given. We then have to decide the dimensions for these zones, margins, and sectors to establish a complete support system which is going to be evaluated.

The dimensions for these zones can be determined by analyzing how well the intended activities fit into zones of different dimensions. For example, for the delta zone in our support system, we have to examine the ideal width of a balcony and the code limitation on it which can be excluded in the building floor coverage. And for the gamma zone, we have to examine the ideal and legally-allowed width of the staircase. For the alpha and beta zones, though it is a little intricate to comprehend the dimension since habitable rooms and service spaces have multiple functions and various layouts, we can still propose certain dimensions for them which will be evaluated later.

A margin is an area between two zones. Spaces always end within these margins. The dimensions of margins reflect certain standards and value judgements which the support system accommodates. For a narrow margin, there is little difference between the minimum and maximum depth a space can have. For a wide margin, there is great room for variations in the depth of the space. (Fig. 4.3)

On deciding sector dimensions, participants refer to the standards of functions that were set up for possible sizes, shapes, and layouts of each function. These standards of functions can be found in the charts discussed earlier. In addition, the dimensions of zones and margins are also references for the decision on dimensions of sectors since they all together form the shape of a space.



(Fig. 4.3) Margin for Flexibility

D. SECTOR GROUPS

A dwelling in a support structure is a combination of interconnecting sectors -- a sector group. Before evaluating layout variants, we have to choose the desired sector groups which are both preferred, according to our contexts, and are valid in the support structure.

There are certain criteria for a sector group to form a dwelling unit within our specific contexts. In the support systems proposed, each alternative has some accompanying rules restricting the possible positions of the party-walls to define a sector group. (Fig. 3.13)

Participants may decide upon the desired sector groups by referring to their specific contexts of people's needs and resources. After deciding upon the desired sector groups, they then set up the complete support system they are going to work on.

4.2 OPERATING

To explore the dynamic dwelling design, we have to evaluate the support design. A support in the dynamic dwelling design, by definition, is a structure which provides choices in the layout of dwelling units. The more the preferred layout variants the support structure can accommodate, the better the support design is.

There are two levels of variation for these layout variants -- sector groups and basic variants. Any part of the support to be used for a dwelling gives a combination of inter-connecting sectors which is called a "sector group". For each sector group, we can find the possible combinations of functions which is called a "basic variant". A basic variant gives no floor plan but represents a set of floor plans that all have the same arrangements in functions.

After we choose different sector groups and check what basic variants each sector group can accommodate, we know what capacity of layout possiblities a support system has. We then can use this knowledgement to evaluate whether the support system is good or bad within our specific contexts.

The exploration of a design problem is a process of solution-investigation. In the exploration process, the participants select and distribute space elements based on the understanding obtained in the norm-setting sphere earlier. When they explore the process of a dynamic dwelling design for multi-family walk-up apartments in Taiwan, the participants use known information in both the system for support structure and the system for good dwellings as heuristic sources to generate design. These norms stimulate design innovations and help the participants conceive alternative layout variations for a dwelling design.

The design variations are then compared with the norms. The layout alternatives are compared and tested to determine if they can be accommodated by the environment, described in the system for support structure, and if they can satisfy the criteria set up in the system for good dwellings. From this testing process, the participants learn the contrasts between the design variations and the norms.

To adjust the relations between the design variation and the norms, one may decide to refine the design variation or revise the norms according to the conflicts learned. The adjusting operation is based on the participants' own value judgements. They may improve the layout variants. They may change the dimensions for zones and sectors. They may also choose different sector groups or even different support principle alternatives.

After the adjusting process, the participants may use these adjusted norms and start another cycle of operations all over again. A number of these cycles are repeated until the design is satisfactory.

Repeating these operating processes for different desired layout variants, the participants can figure out what preferred basic variants a given sector group can accommodate. After they select different sector groups in a support system and test whether preferred layout variants can be accommodated in them, the participants can have a better idea about the possible layouts in a support structure they choose. Thus, the participants may evaluate different support systems with different dimensions and relationships among its space elements.

At this stage, when the whole evaluation process is completed, participants obtain a throughout understanding in all the norms to which the dynamic dwelling design comforms. This final, definite set of norms about the support system and good dwellings, are expressed in the final variations. It is not important where the participants start, but as long as the process is completed and the support design is finished, all the norms must be documented to explain the layout possibilities of the support.

Such formal documents, however, do not dictate which variations will be used when a support has been built. They simply indicate the criteria used in the design and suggest the possibilities. Also, they are the means of communication among different participants in the design process. Other variations and sub-variations can, and probably will, arise when individual residents plan their own dwellings.

CHAPTER 5

CHAPTER 5 USING A COMPUTER IN THE PROCESS

"Computer-aided design" uses a computer as a tool that replaces pencils in the design process. So, a computer-applied design model developed here should achieve what a designer usually does on the drafting board during the course of design. Thus, creative work is still human work. The machine is not the decision-maker that takes full responsibility for the design.

Using computers in architectural design, architects may save their time spent in the traditional way of working. And they can concentrate on the creative aspect of design. To save time, they assign computers the tasks of routine work and trivial calculations. Therefore, they can put more effort and time into the creative design work which they prefer and are best at doing.

For architects interested in the use of computers, the important issue is not the program, but the process of building it. The process presents a different way of looking at a problem or an issue. At the same time, it provides a vehicle to understand procedures to achieve a goal. As long as we have more and better understanding about the design behaviors, we can feel more confident to elaborate a better computer model for design. In my study, I followed this direction to explore the benefits and to portray the goals of using computers in the process of dynamic dwelling design.

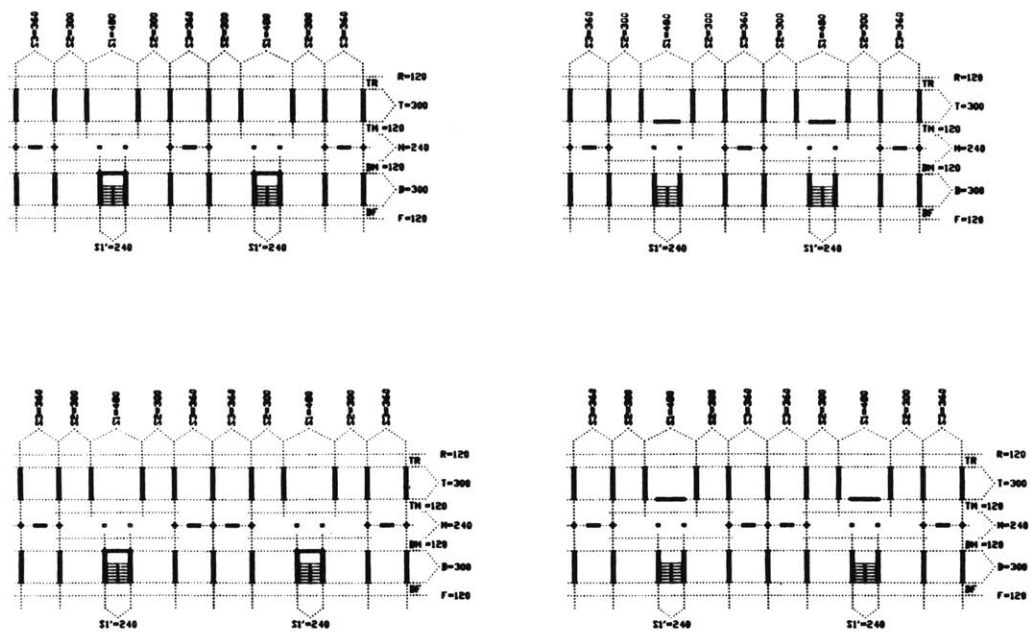
In a dynamic dwelling design, one has to evaluate the support design by examining whether the support structure can accommodate the preferred layout variants which satisfy the criteria for dwelling quality. This is an issue of test-and-satisfy rather than a generate-and-optimize one. Instead of generating all possible variations which include undesired ones, the participants only check whether a desired proposal is within the norms of the constraint. Thus it is reasonable and easy to apply computers within their practical computational limit.

The better support for the dynamic dwelling design is the one which can accommodate more layout variations of the system for good dwellings. The evaluation process, therefore, is a huge effort of "trial-and-error". One has to test different layout variations and different support systems with various dimensions and relations in the space elements. This is an issue of experie-nce. For people less experienced in designing dwellings, such as users and developers, they may spend a lot of time and effort in checking all these layout variations and different support systems. Using a computer can speed up the huge task of "trial-and-error" in the evaluation process.

The design model here does not describe the step-by-step sequences but the relationships of operations in the design process. Therefore the design process itself is dynamic and depends on the roles of the participants as well as their experiences, interests and values. It can make the indefinite design process not only possible but also an easy one to use a computer with systematically formulated and easily retrievable norms. The participants may conceive of these operations as a kit of tools. They may use this tool kit at their convenvience in the dynamic design process.

When the whole evaluation process for a dynamic dwelling design is completed, all the norms to which the dynamic dwelling design conform are determined. A computer can document the final, definite set of norms and possible layout variations accumulated from the evaluation process. Individual residents then can easily plan their own dwellings with these retrievable norms and suggested layout variants on the computer. This makes "user participation" not only easy but also possible without the help of an architect.

In the following, I will give a general description on the operations of the model without getting into the detailed operation process of the computer model. This model divides the task into man's work and machine's work as follows:



(Fig. 5.1) Support Alternatives with Default Dimensions

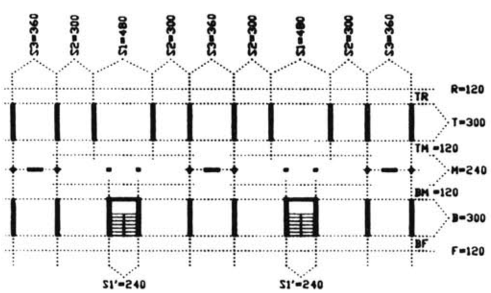
5.1 MAN'S WORK

Since there is no fixed sequence of operations in the model, this is just a general description on the operations of the computer-applied dynamic dwelling design model. The description is from the participants' point of view while using the model. The sequence of the process depends on the participants' roles, values, experiences and intuition. They may start from any operation and return to it whenever they wish. We can briefly separate these operations into two aspects -- norm-setting and operating, as follows:

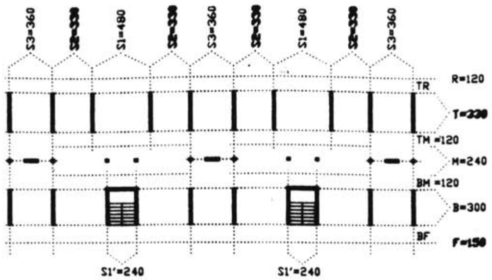
A. NORM-SETTING

* Select a Support Principle

In each support principle of the four alternatives, the zone distribution is already given. (Fig. 5.1) Also the positions and placements of ducts and stairs are accompanied. The position rules are composed in each alternative by means of zone/sector. Whenever it is chosen, the support principle should show default dimensions and default position rules. (Fig. 5.2)



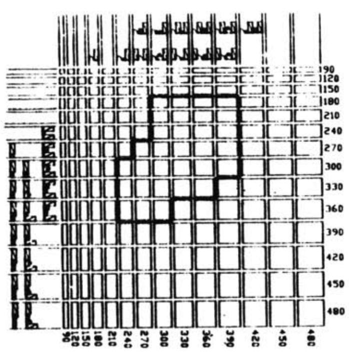
(Fig. 5.2)



(Fig. 5.3)

L	TS1,MS2,BS2	TS1	K,KD,L,MB,B2
D	MS2	TS2	K,B1,B2
LD	MS2,BS2	TS3	MB,B1,B2
MB	TS1,BS2,BS3	MS1	S,St,b,b1,b2,K1
B1	TS2,TS3,BS3	MS2	L,D,LD
B2	TS1,TS2,BS3	MS3	St,b,b1,b2,K1
K	TS1,TS2	BS1	S
K1	MS1,MS3	BS2	L,LD,MB
KD	TS1	BS3	L,MB,B1,B2
S	BS1		
St	MS1,MS3		
b	MS1,MS3		
b1	MS1,MS3		
B2	MS1,MS3		

(Fig. 5.4)



(Fig. 5.5)

* Decide Dimensions of Zones/Sectors

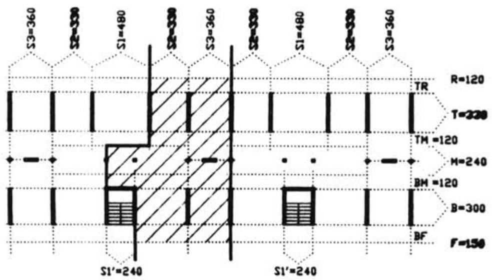
A participant may decide to change or retain the default dimension for each zone, margin or sector. The newly set up dimensions then should be reflcted in the drawing on the screen. (Fig. 5.3)

* Decide Position Rules of Functions

Though the position rules are composed by the chosen support principle, a participant may still add or alter rules which he prefers. He first inspects each default position rule then makes necessary adjustments. (Fig. 5.4)

* Decide Standards of Functions

With the help of space charts, a participant may choose the desired standard range for each function. By drawing lines on the charts, the participants decide the minimum and maximum dimensions as well as the minimum and maximum areas for each function. (Fig. 5.5)



(Fig. 5.6)

* Select a Sector Group

A participant may draw the party-wall lines on the screen to choose a desired sector group. The sector group chosen should be both preferred within the contexts and valid in the support structure. (Fig. 5.6)

B. OPERATING

* What Functions Fit Here?

A participant may ask the computer what functions will fit into a particular place in the sector group. The computer would list all the appropriate functions for the location according to the position rules set up earlier. (Fig. 5.7)

*What space functions fit MS1?

TS1	K,KD,L,MB,B2
TS2	K,B1,B2
TS3	MB,B1,B2
MS1	**S,St,b,b1,b2,K1**
MS2	L,D,LD
MS3	St,b,b1,b2,K1
BS1	S
BS2	L,LD,MB
BS3	L,MB,B1,B2

(Fig. 5.7)

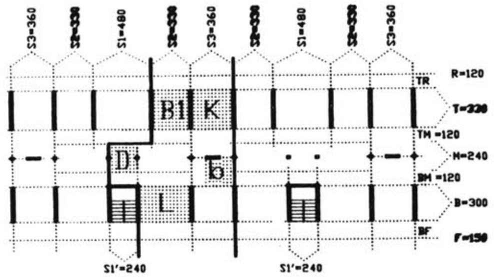
* Where Can This Go?

A participant may also ask the computer what possible places in the sector group a particular function will fit into. The computer would list all the possible places for the function according to the position rules set up earlier. (Fig. 5.8)

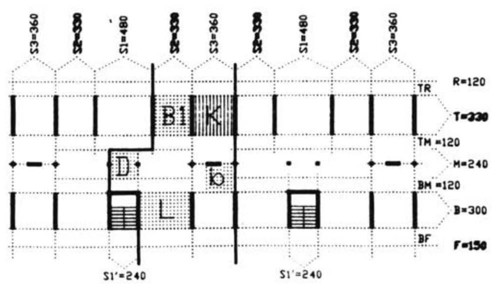
*Where can **Master Bedroom** go?

L	TS1,MS2,BS2,BS3
D	MS2
LD	MS2,BS2
MB	**TS1,BS2,BS3**
B1	TS2,TS3,BS3
B2	TS1,TS2,BS3
K	TS1,TS2
K1	MS1,MS3
KD	TS1

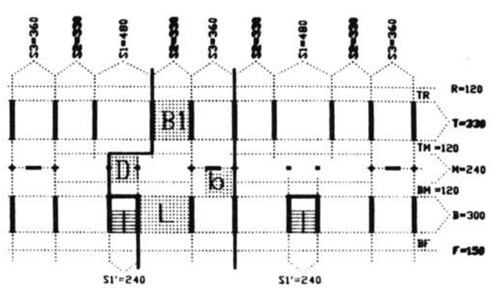
(Fig. 5.8)



(Fig. 5.9)



(Fig. 5.10)



(Fig. 5.11)

* Place Functions

A participant may place each function into a zone or a margin of the sector group. When all functions from the program of a dwelling have been assigned a position in the zoning, a basic variant has been hereby completed for testing. (Fig. 5.9)

* Show Contrasts

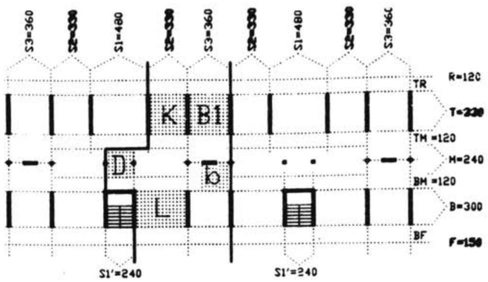
The contrasts, both local and global are shown by comparing the function placed and the whole basic variant against the norms set up earlier. There are positional and dimensional violations in the contrasts which a participant can use as references to adjust the norms or refine the layout variant. (Fig. 5.16)

* Remove Functions

A participant may remove functions to adjust the contrasts shown in the testing process. Then he may reassign the removed functions to other positions in the zone/sector for testing. (Fig. 5.11)

* Switch Functions

A participant may remove and replace functions altogether to switch the positions of two functions in a basic variant. This is to adjust the contrasts or to form another basic variant for testing. (Fig. 5.12)



(Fig. 5.12)

* Change the Position Rules

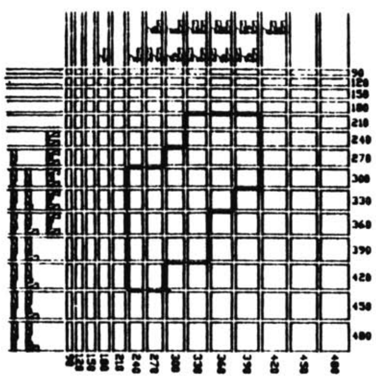
To adjust the norms, a participant may go back to the norm setting process and change the position rules set up earlier. The procedure is the same as the "Decide Position Rules" operation in the norm-setting process. (Fig. 5.13)

L	TS1,MS2,BS2,BS3
D	MS2
LD	MS2,BS2
MB	TS1,BS2,BS3
B1	TS2,TS3,BS3
B2	TS1,TS2,BS3
K	TS1,TS2
K1	MS1,MS3
KD	TS1
S	BS1
St	MS1,MS3
b	MS1,MS3

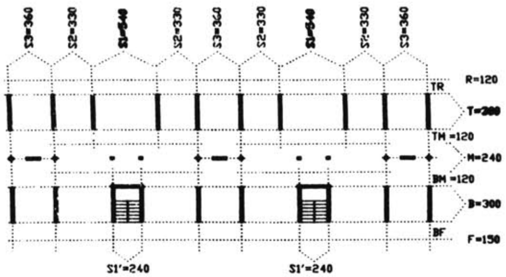
(Fig. 5.13)

* Change the Standards of Functions

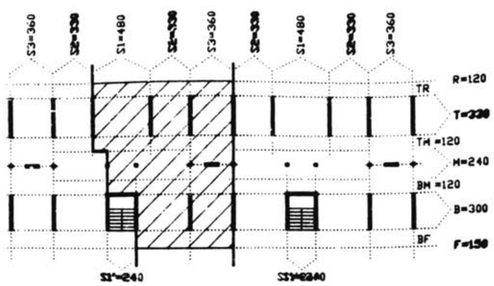
A participant may also like to change the desired standard range to adjust the contrasts. With a space chart, the procedure is the same as the "Decide Standards of Functions" operation in the norm-setting process. (Fig. 5.14)



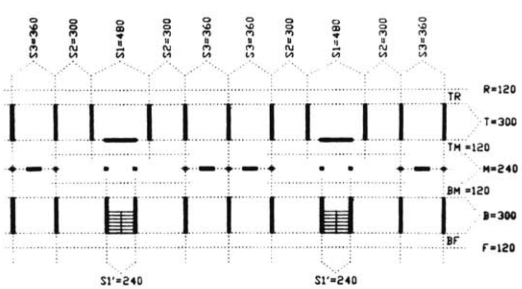
(Fig. 5.14)



(Fig. 5.15)



(Fig. 5.16)



(Fig. 5.17)

* Change the Dimensions of Zoning

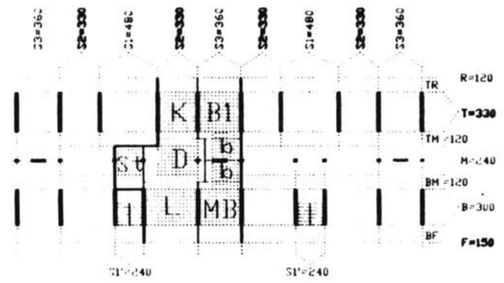
A participant may also like to change the dimensions of zones, margins, or sectors. By going through each zone, margin, and sector, the procedure of changing is also the same as the "Decide Dimensions of Zoning" operation in the norm-setting process. (Fig. 5.15)

* Change the Sector Group

A participant may select another sector group for evaluation when all the possible basic variants have been tested, or when the sector group chosen is not suitable. The procedure is the same as in the norm-setting process. Changing a sector group, the participant may retain other norms as the same. (Fig. 5.16)

* Change the Support Principle

After working a while, a participant may conclude that the support system is simply inappropriate, and decide to choose another one. If the support principle should be changed, the participant may need to start the whole norm-setting process all over again. (Fig. 5.17)



(Fig. 5.18)

FUNCTION	minX	maxX	minY	maxY	minA	maxA	POSITIONS
B1	240	330	330	420	64800	138600	TS2,BS3,TS3
B2	360	420	360	480	129600	201600	TS2,TS3.BS3
K	180	240	270	420	48600	100800	TS1,TS2
D	180	330	210	330	37800	108900	TS1,MS1.MS2
KD	270	480	330	450	89100	216000	TS
b	150	270	120	240	18000	104800	MS1.MS3
b1	150	210	90	210	13500	43200	MS1.MS3
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

POSITION	minX	maxX	minY	maxY	minA	maxA	FUNCTIONS
TS1	480	480	300	540	144000	259200	K,KD.L.MB.B2
TS2	300	300	300	540	90000	162000	K,B1,B2
TS3	360	360	300	540	108000	194400	B1.B2.MB
MS1	240	480	240	480	57600	230400	St,S.b.b1,b2
MS2	300	420	240	360	72000	151200	L,D.LD
MS3	240	360	240	360	57600	129600	St.b,b1,b2
BS1	240	240	300	420	100800	129600	S
BS2	420	420	300	420	12600	176400	L.LD.MB
BS3	360	360	300	540	108000	194400	L,MB,B1.B2

(Fig. 5.19)

* Implement Basic Variants

The functions placed in the sector group are tested with norms set up earlier. After the testing and adjusting process have been done and the results are valid, the design action of placing functions in the site can be implemented as a basic variant. (Fig. 5.18)

* Document Norms

After testing all the preferred layout variants, a participant may conclude that the norms are acceptable. At that time, all necessary information on the functions and the zoning are stored automatically in the computer data base. (Fig. 5.19) In a later stage, the information stored can be retrieved for specific purpose of use.

5.2 MACHINE'S WORK

The computer tracks throughout the participants' operations by maintaining information and performing operations. The following contexts will describe the internal mechanism of the computer-applied design model from the computational point of view.

A. INFORMATION MAINTAINED

There are two categories of data stored in the computer data base -- support system and space functions. In each category, there are three types of data -- names, positions and dimensions. The information can also be retrieved from the computer data base. This information describes the permitted, actual or suggested positions and dimensions of functions related to the support system. Each change that the participant makes causes a change in the date base.

In some cases, one change initiates an entire chain of changes as a consequence. The norm propagating the database, therefore, must clearly represent dependencies among data items.

When one datum changes, all dependent data immediately change to remain consistent in the data base.

* Data of Support System

The support system in this case consists of five zones, namely, the Top zone, Middle zone, Bottom zone, Front zone and Rear zone. TR, TM, MB, BF are margins between the zones. Combined with the sectors, each subdivided space can be named. The zoning provides the spatial contexts and also describes the spatial relationships among them. In the data base there is a list of functions considered appropriate for each zone or margin.

For each subdivided space, the major properties are its X dimension and Y dimension. The dimensions of a zone represent the minimum depth of a location. While the dimensions of a zone plus adjacent margins will be the maximum depth of a location to place a function.

* Data of Space Functions

Space functions are named by the conventions of users, i.e. living, dining, etc. There are also position and dimension properties stored for each function. The dimensional data for each function are expressed by minimum and maximum dimensions for its width and depth as well as minimum and maximum area. In the data of function, there is also a list of zones and margins considered appropriate locations for each function.

B. OPERATIONS PERFORMED

The computer model contains three major parts. Each part has a specific task stated as follows:

* Set and Get Information

There is a language for storing, querying and changing the data base which deals with position and dimension properties of both zoning and functions. This work includes setting, viewing, and revising information in the data base.

The position rules initially accompany each support alternative. This information is stored in the data base by listing all the approriate locations for each function and appropriate functions for each location. The participants may, whenever they want, call out these rules, add new ones or change specific ones.

FUNCTION	minX	maxX	minY	maxY	minA	maxA	POSITIONS
B1	240	330	330	420	64800	138600	TS2,BS3,TS3
B2	360	420	360	480	129600	201600	TS2,TS3,BS3
K	180	240	270	420	48600	100800	TS1,TS2
D	180	330	210	330	37800	108900	TS1,MS1,MS2
KD	270	480	330	450	89100	216000	TS
b	150	270	120	240	18000	104800	MS1,MS3
b1	150	210	90	210	13500	43200	MS1,MS3
.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.

POSITION	minX	maxX	minY	maxY	minA	maxA	FUNCTIONS
TS1	480	480	300	540	144000	259200	K,KD.L,MB.B2
TS2	300	300	300	540	90000	162000	K,B1,B2
TS3	360	360	300	540	108000	194400	B1,B2.MB
MS1	240	480	240	480	57600	230400	St,S.b,b1,b2
MS2	300	420	240	360	72000	151200	L,D,LD
MS3	240	360	240	360	57600	129600	St,b,b1,b2
BS1	240	240	300	420	100800	129600	S
BS2	420	420	300	420	12600	176400	L.LD.MB
BS3	360	360	300	540	108000	194400	L.MB.B1.B2

(Fig. 5.20) Information Stored

(Fig. 5.20 a,b)

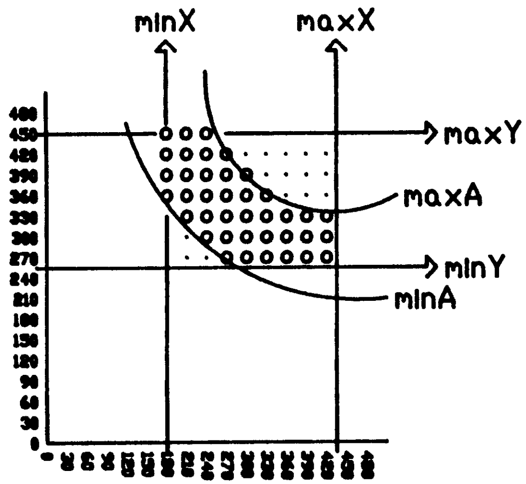
The dimensional information is composed in each function and subdivided space of the support system. There are both desired dimension ranges for each function and possible dimension ranges for each location in the support system.

The computer model also allows the subset of the database to be stored and retrieved in a more durable way. The participant should be able, at his discretion, to store the valid basic variants and all the necessary norm sets about the functions and support system.

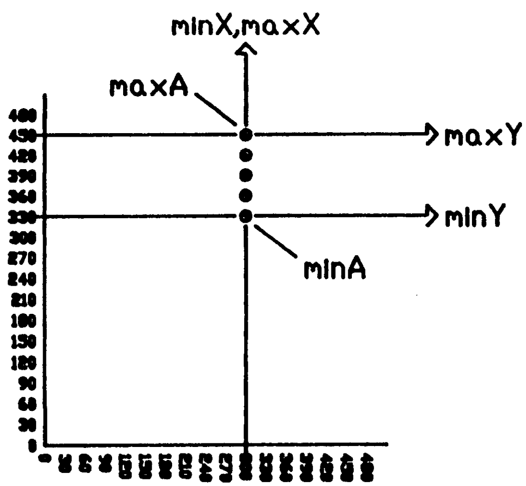
* Check Norms

Checking is a chain of reasoning processes, regarding the conditional situations. It starts from examining the position rules for each input function in the sector group. Next it deals with a series of conditional analyses with respect of dimensions.

For positional checking, the computer simply checks whether this location is valid for the function placed in it according to the position rules set up earlier. For positional violation, there are only two things the participant can do: either change



(Fig. 5.21a) Desired Dimension Range of the Function



(Fig. 5.21b) Possible Dimension Range of the location

the rules or relocate the function.

For dimensional checking, the computer compares the desired dimension range of a function with the possible dimension range of the location where the function is placed. (Fig. 5.21a,b) If there is any intersection of these two dimension ranges, the function placed in this location of the zoning is valid and accepted. If not, a dimensional violation would be pointed out. (Fig. 5.22) A participant then may consider whether to replace the function or to change the dimensions of the zone, margin or sector. He may also reconsider the desired dimension range of the function.

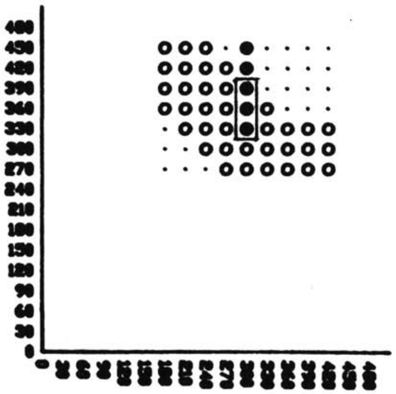
* Implement Input

There are drawing tools to display on the screen the support structure, space charts, functions placed, and basic variants. They can also show the names and dimensions of each function and zoning with alphabets. (Fig. 5.23)

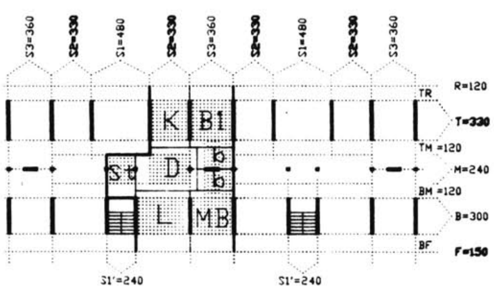
This graphic editing language must allow the computer to draw the support structure on the screen automatically whenever the information on the support structure is set or changed. (Fig.

5.24) It also allows the participants to select a sector group by drawing the party-wall lines. (Fig. 5.25) It also allow the participants to decide a desired dimension range for each function by drawing the lines on the space chart. (Fig. 5.26)

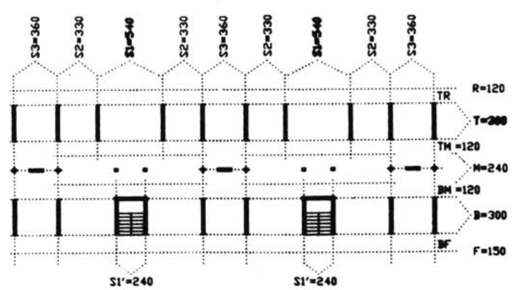
Approximate dimensions and positions are good enough to form a basic variant, so long as the constraints imposed on the dwelling design are not violated. The graphic editing language must allow the participant to place functions approximately without indicating precise dimensions or positions. (Fig. 5.27)



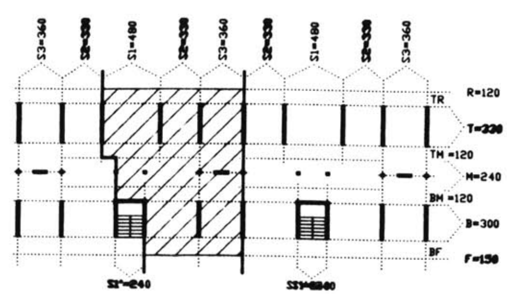
(Fig. 5.22) Intersection



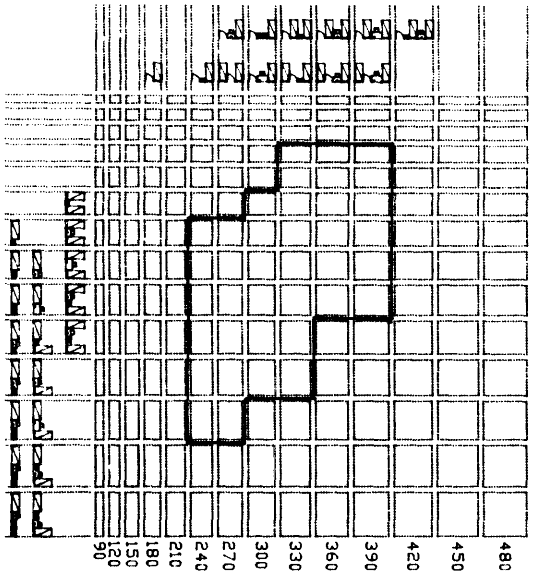
(Fig. 5.23)



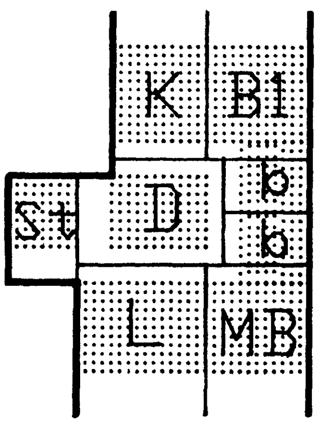
(Fig. 5.24)



(Fig. 5.25)



(Fig. 5.26)



(Fig. 5.27)

5.3 AN EXAMPLE

The process of this model for the dynamic dwelling design is indefinite. There is not a step-by-step sequence of operations in the process. The sequence of operations depends on the roles of the participants who use this model. The participants can be an architect, a developer, or users involved in the design problem of a dynamic dwelling.

The following is an example of possible process taken by a developer. This example illustrates how this model helps a developer to explore a dynamic dwelling design for multi-family walk-up apartments in Taiwan.

Mr. Chen, a developer with a site in hand, he is going to build a field of dynamic dwellings for multi-family walk-up apartments. Hence, he has some notions about the site situation and the user group he is working on. Given these contexts and the model of dynamic dwelling design, he is now going to design a suitable support system with appropriate dimensions which serve rightly for the contexts he possesses.

With the contexts in mind, he starts with setting up the criteria for a "good" dwelling from his experiences of direct access to the occpupants with needs and resources. With this understanding, he chooses a support system with dimensions which he thinks suitable for his program. Then, he evaluates it by its capacity. Since there are two levels of variations -- sector groups and basic variants, used to evaluate a support system, he begins with choosing a sector group which is one of the desired dwelling site within the contexts.

After selecting a sector group, he then checks whether the desired basic variants are valid in the sector group and whether they satisfy the criteria for good dwellings. The basic variants are generated by placing functions in the sector group. When one basic variant from the contexts has been made and tested, he may procede to another basic variant until all preferred possibilities have been exhausted.

During the checking process, he might find contrasts between the norms set up earlier and the desired layout variants. Under his own value judgement, he then may go back to revise the norms or just cross out the layout variants. He may change the dimensions of the support systme or may even decide to choose another support alternative. After checking different layout variants and different support systems with different dimensions, he can come out with a support design which is satisfactory within the contexts he is working on.

Finally, he finishes the exploration of the dynamic dwelling design by documenting all these final norms and possible layout variants. When individual residents get into the process later, they then can use these documentations as suggestions to plan their own dwelling.

CHAPTER 6

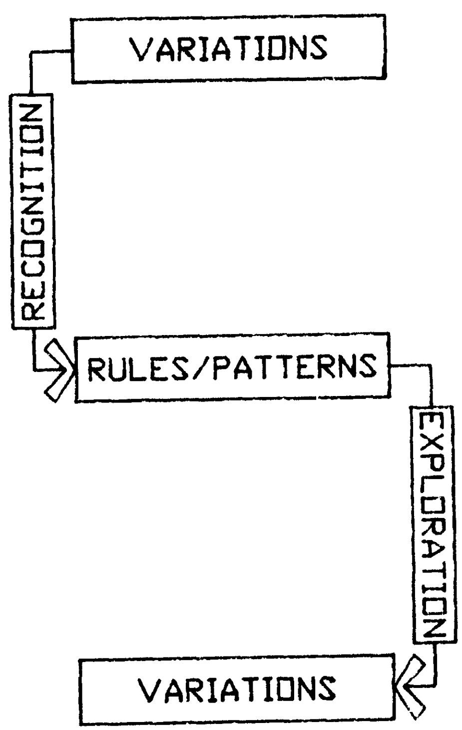
CHAPTER 6 THEORETICAL BACKGROUND OF THE DESIGN MODEL

In this final chapter, it is appropriate to present the theoretical background for the design model developed in this thesis -- a computer-applied dynamic dwelling design model for multi-family walk-up apartments in Taiwan. The theoretical discussion may answer some questions that have arisen from the study of this model. In addition, such an examination may stimulate further theoretical studies in the future.

A design model describes the process of design. It explains the way to design. However, it is difficult to describe a design process because it includes so many intangible elements such as intuition, imagination, and creativity. However, describing the design process may help designers understand their own behaviors in designing and thereby improve their design ability.

The usefulness of a design model lies not only on its adequacy as a description but on its value as an aid to raise effectiveness in design. The design process described here is not a step-by-step sequence. It does not describe the sequence of operations but the relationships among them. These operations constitute a kit of tools. With different experiences, interests, and intuition, designers may use this kit of tools in the design process at their convenience.

Looking at design in this way, we may separate a design task into two aspects of expertise -- recognition and exploration -- that help to make design decisions. Architectural design requires the abilities to recognize patterns in built-environment, and then to organize spaces and materials based on that understanding. The recognition ability enables a designer to observe patterns from a set of variations and to set up systems describing patterns. The exploration ability enables designers to make variations which are subject to these given set of rules in the systems. (Fig. 6.1)



(Fig. 6.1)

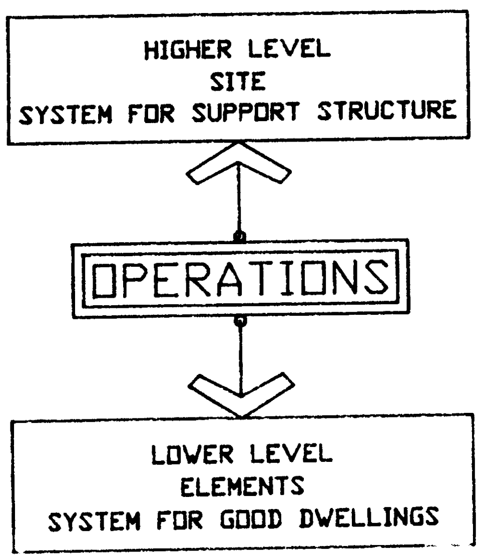
6.1 RECOGNITION PROCESS

The man-made environment always reveals certain consistent rules which can be used as guidelines for design. Through analyses on space morphology and space needs over time, one may generate explicit rules to describe the built-environment. The rules or principles can then be used to develop a system to guide design. Though these rules are not universally true, they reflect specific contexts of time, space, and people involved.

Recognition is a kind of problem-formulation process. It searches for specifications of desired properties of solutions. The specifications serve as the criteria for design solutions. From the recognition process, one can observe and generate rules to form systems guiding the design. These rules are rationally organized and explicitly formulated so that they can be easily retrieved and used as coordinates for individual decision. The term "system" and "variations" are ways of indicating the ideas that the environment can be described on the basis of systemic rules which the observer can recognize from the built environment.

In any design problem, there is always a site and a set of elements. The elements are placed in the site. So, the participants in the design process must have 1) the description of the site, 2) a defined set of elements that can be used in the site, 3) data on the locations of elements, relative to one another, and 4) data on the locations of elements in the site. To solve the dynamic dwelling design problem, the information on the site and the elements must be described explicitly as a system which all the participants can understand in order to communicate with ease.

In the dynamic dwelling design process, one checks whether the support structure can accommodate the preferred layout variants which satisfy the criteria for good dwellings. Thus the design problem can be seen as the relation between two space systems in two levels. One is the space system for the support structure -- the higher level. And the other is the system for good dwellings -- the lower level. The system for support structure provides information on the site which will accommodate the space elements of the system for good dwellings. (Fig. 6.2)



(Fig. 6.2)

A. SYSTEM FOR GOOD DWELLINGS

A system is a set of clearly defined elements plus a description of the relationships among them. The elements in the system for good dwellings are spaces identified by their dimensions and functions. The relationships among the space elements are their relative positions. These positions depend on their dimensions, functions, and other properties.

From a formal and systematic analysis on spaces and functions, one may obtain orderly and clear information on the sizes, shapes, and possible layouts of each function. Once the space elements in a set have been defined, standards then can be set up in the positions of spaces relative to each other on the basis of the functions.

A set of coordinated standards can be used to describe what a "good" dwelling is. Such a combination of standards is a description of the system for good dwellings. These standards are pre-determined agreements, which are only valid for a specific span of time, within specific contexts and for specific people. These standards always reflect certain value judgements of the participants involved in the design.

B. SYSTEM FOR SUPPORT STRUCTURE

A support structure in the dynamic dwelling design should accommodate a variety of dwelling layouts. This means that the support is also a combination of spaces as a space system. The support structure is the environment which accommodates the space elements of the system for good dwellings. A support system is a set of formally defined elements and relationships among them.

The elements of this space system are the spaces defined as "sectors" by the floors, walls, and columns of the support structure. These spaces are also related to one another according to certain conventions by the people involved.

A formal description is needed not only to make this space system explicit but also can be applied in the dynamic dwelling design. To achieve this, we use the "zoning" concept to contain information on dimensions and locations of spaces in the system for support structure. It gives reference positions for the floorplan and limits the size of functions which may be placed. What is called a dwelling type is recognized by a particular combination of zones with information on locations and dimensions of spaces in the zoning.

6.2 EXPLORATION PROCESS

The exploration process of a dynamic dwelling design is a kind of solution-investigation process. In this process, designers organize spaces and material elements based on the understanding from the recognition process. During the exploration process, designers select and distribute elements that are subject to a given set of norms. This set of norms are expressed by two space systems in two different levels -- the system for support structure (the higher level) and the system for good dwellings (the lower level).

These two levels are connected by means of operations concerning the selection and deployment of lower level elements, space functions, in the support structure, a higher level variation. Designers select elements on the lower level and distribute them in the environment provided by the higher level.

The operations can be considered as one in which several phases of operations exit -- generating, testing, adjusting, and documenting. These operations which are in the exploration process of a design are always based on the norms set in the recognition process.

A. GENERATING

Norms set for design are useful not only because they can be a body of knowledge for evaluation but also as an heuristic catalyst for the creation sphere in design. Since generating is a kind of arbitrary creative leap, designers use norms heuristically as empirical sources for cognitive design decisions in the generating process. Designers use their vision of eventual solutions to more clearly define the design problem they are working on. And the vision can also guide designers with their search for answers. In the generating process of a dynamic dwelling design, the designers use available information on both space systems, the system for support structure and the system for good dwellings, as heuristical sources. This information can then stimulate design innovations and help designers conceive preferred layout variants for a good dwelling.

B. TESTING

After proposing a tentative design variation, designers step backward with a critical eye to compare the design variations against an array of norms set for the design in the recognition process. Testing in the design process replaces blind searching for alternatives with an intelligent one that uses explicit norms to evaluate design variations. In a dynamic dwelling design, layout variations are compared with the norms of the two space systems. This means that the preferred layout variants must be accommodated by the system for support structure. In addition, the variants have to satisfy the criteria from the system for good dwellings. From this testing process, one may learn the contrasts between the design variations and the norms.

C. ADJUSTING

After learning the contrasts from the testing process, designers step forward again to adjust the relations between the design variations proposed and the norms the proposal intends to meet. To adjust the relations, designers may either refine the design variations or revise the norms. They may improve the design variations according to the norms they intend to meet. They may also revise the norms by adding or changing the norms of the two space systems. While adjusting, designers are preparing for the next creative leap. Using the adjusted norms, they start another operation cycle all over again. A number of these cycles are repeated until the design is satisfactory.

D. DOCUMENTING

A support structure in the dynamic dwelling design, by definition, should provide as many desired layout variations as possible. Designers repeat the cycling design process to evaluate different layout variations and different support systems with different dimensions and relations in its space elements. After this whole evaluation process is completed, all the norms are determined to which the dynamic dwelling design conforms. This final, definite set of norms are in the system for support structure and in the system for good dwellings. The norms must be documented to explain the layout possibilities of the support design. Such formal documents indicate the criteria in design and also suggest the possible layout variants in a dynamic dwelling design. They provide the means of communications between different participants who may join the design process later.

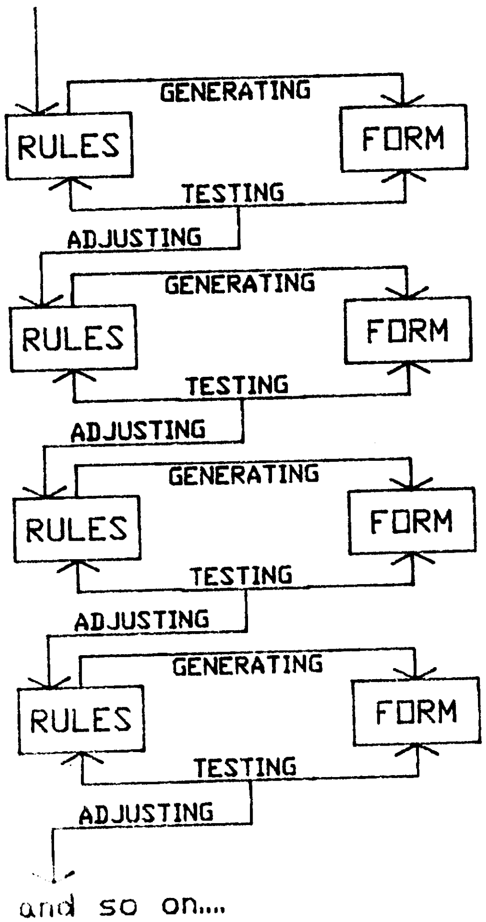
6.3. CHARACTERISTICS OF THE MODEL

A. DYNAMIC DWELLING DESIGN

The theory behind this design model can be described as using the concept of a "system". Every building can be considered as a space system in which the spaces are components, and the relationships among these spaces conform to certain rules. The system thus indicated rests on "agreements" expressed in the selection of elements and their rules of distribution in space. However, these agreements are not necessarily an universal truth but simply conventions among a group of people involved in a design problem. One composition of elements allowed within a system is a variation of that system. The variation must be arranged according to the relational rules of that system.

This design model applies the design process as a developmental process. The norms given to the design are not initially coherent. Yet the norms emerge as the problem is being explored. As the process makes contrasts apparent, designers learn from it and realize a shortage of norms. Hereby, problem-definition and problem-solution proceed simultaneously, and designs develope cumulatively. Also, designers can at any time draw on additional rules to refine the problem. Through the exploration process, designers can progressively improve their work by adjusting proposed ideas or revising norms.

A decision in one cycle may determine the contexts for decisions in the next. The design process repeats a series of operations again and again. The design can be finished completely or decisions can be left unmade for others joining the work later. (Fig. 6.3)



(Fig. 6.3)

Another basic concept raised here is that of "level". Variants at the same level follow an agreed-upon set of rules. They provide, once made, the context for lower level interventions. While they find themselves in a context composed by a higher level variant. In this manner, a designer finds himself accepting another designer's higher level variants as a context. In sequence, he hands down a solution for someone else who can make design decisions on a lower level later.

In this design model, the design can be left unfinished. The final set of norms are documented to indicate the criteria and also to suggest the possibilities for those who join the work later. Using this concept in the dynamic dwelling design, we provide the means of communication for different participants in the process. Individual residents can plan and change their own dwelling to reach the dynamic dwelling design.

B. COMPUTER-APPLIED DESIGN

This design model is a constraint-satisfaction problem rather than an optimization one. With the concept of optimization, designers can not recognize the best alternative until they have seen all of the possible alternatives. But, in this model, the constraints given to the design are not initially completed. Designers begin with a simple problem and they cumulatively develop into more complex problems.

It is difficult for a computer to generate all the admissible alternatives within practicable computational limits. Besides, it is meaningless to generate all possible variations which inculde undesired ones. However, it is reasonable and easy for the computer to check whether a desired proposal is within the constraints.

Satisfication means a degree of acceptability in fitness of a form in question and its contexts. With the concept of satisfication, designers check desired variants against the norms of constraints. This model then enables designers to deal with multiple constraints simultaneously. It also treats the tensions among contraints as heuristical sources to generate creative resulations. With this model, we introduce rational testing and adjusting along with creative generating. This not only allows creative imagination flow in the design process but also finds the feasibility of computer applications in the rational testing process.

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